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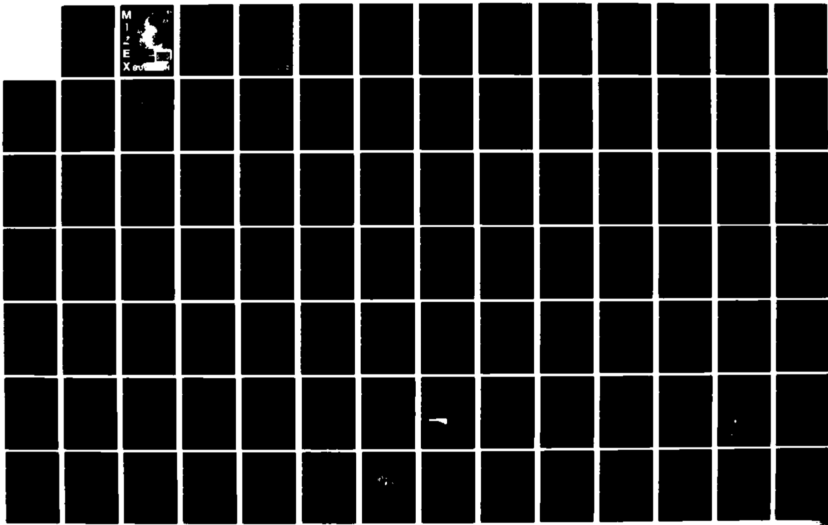

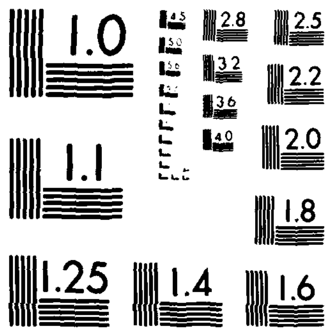

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MIZEX

V: MIZEX 84 SUMMER EXPERIMENT PI Preliminary Reports

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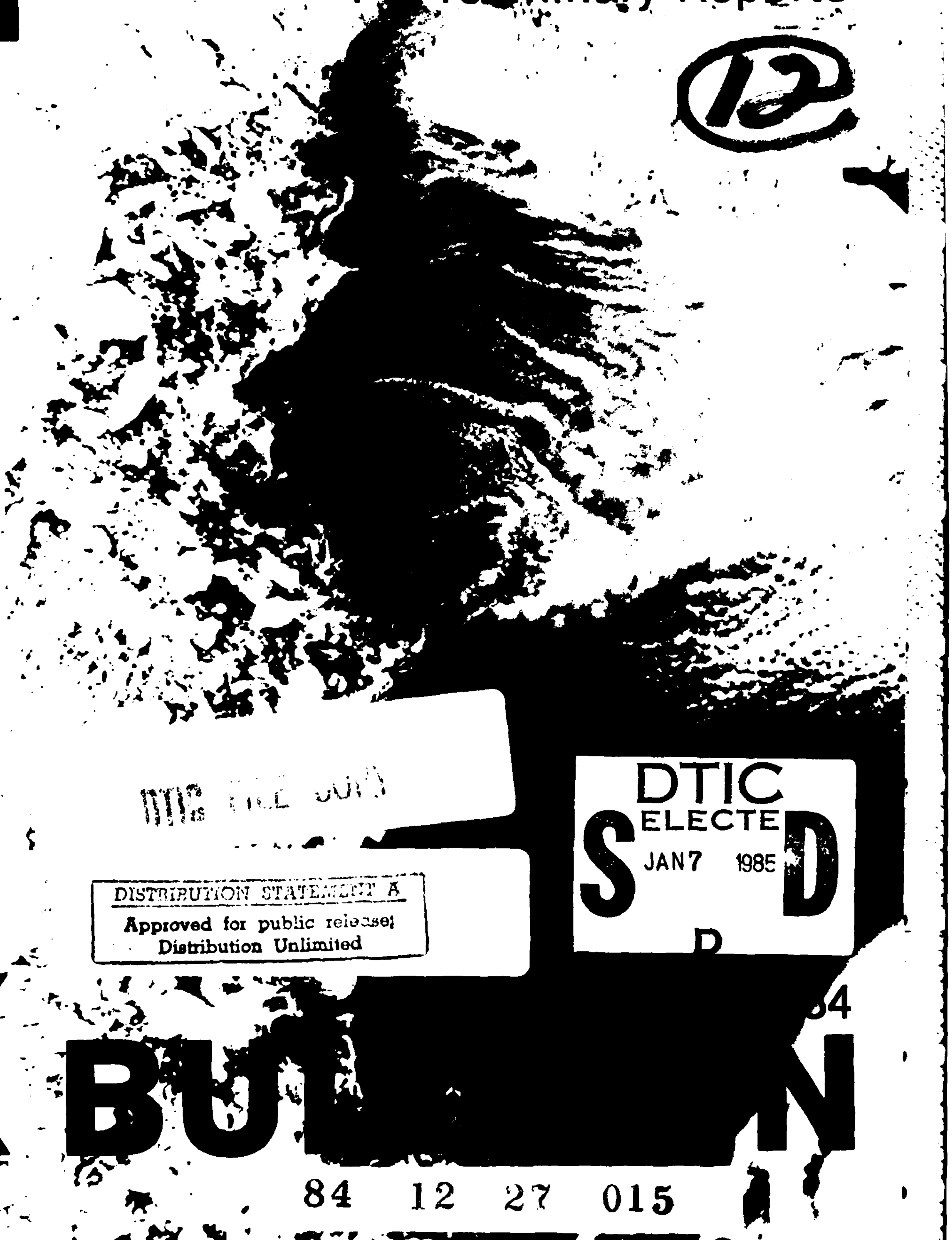

84

BULLETIN

MIZEX BULLETIN SERIES: INFORMATION FOR CONTRIBUTORS

The main purpose of the MIZEX Bulletin series* is to provide a permanent medium for the interchange of initial results, data summaries, and theoretical ideas relevant to the Marginal Ice Zone Experiment. This series will be unrefereed and should not be considered a substitute for more complete and finalized journal articles.

Because of the similarity of the physics of the marginal ice zone in different regions, contributions relevant to any marginal ice zone are welcome, provided they are relevant to the overall goals of MIZEX.

These overall goals are discussed in Bulletin I (Wadhams et al., CRREL Special Report 81-19), which described the research strategy, and Bulletin II (Johannesen et al., CRREL Special Report 83-12), which outlined the science plan for the main 1984 summer experiment. Copies of earlier or current bulletins may be obtained from the Technical Information Branch, USA CRREL.

Persons interested in contributing articles to the bulletin should send copies to one of the editors listed below with figures reproducible in black and white. Proofs of the retyped manuscripts will not be sent to the author unless specifically requested.

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* The MIZEX Bulletin series is funded by the Office of Naval Research.

Cover: Landsat image of the East Greenland marginal ice zone, the location of the main MIZEX 84 summer experiment.

MIZEX
A Program for Mesoscale Air-Ice-Ocean nteraction Experiments in Arctic Marginal Ice Zones

V: MIZEX 84 SUMMER EXPERIMENT PI Preliminary Reports

Ola M. Johannessen and Dean A. Horn, Editors

October 1984

U.S. Army Cold Regions Research and Engineering Laboratory
Hanover, New Hampshire, USA

CRREL Special Report 84-29

PREFACE

The main goal of the Marginal Ice Zone Program (MIZEX) is to understand the mesoscale processes that dictate the advance and retreat of the ice margin. The plan for MIZEX 84 is outlined in "A Science Plan for a Summer Marginal Ice Zone Experiment in the Fram Strait/Greenland Sea: 1984" by O.M. Johannessen et al., CRREL Special Report 83-12, May 1983 (MIZEX Bulletin II).

This MIZEX Bulletin contains the Field Coordinators' summary overview and each Principal Investigator's preliminary report for the MIZEX 84 Summer Experiment which took place in the Fram Strait between Svalbard and Greenland from 18 May to 30 July 1984.

O.M. JOHANNESSEN
Chairman, MIZEX Science Group

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MIZEX 84: A BRIEF OVERVIEW

Ola M.Johannessen and Dean A.Horn

The 1984 Marginal Ice Zone Experiment (MIZEX 84), seeking to understand the mesoscale processes that dictate the advance and retreat of the ice margin, was conducted in the Fram Strait area between Greenland and Svalbard during the period 18 May to 30 July 1984. The culmination of over four years of planning and a continuation of summer MIZEX 83, this 1984 international Arctic research program utilized the resources and expertise of ten nations. MIZEX 84 is the largest coordinated Arctic experiment conducted in the marginal ice zone and has the unique feature of an ad hoc organization established by the scientists themselves without any intergovernmental agreements, memoranda or treaties. This has proved to be an effective scheme for planning and conducting both MIZEX 83 and 84 field operations.

The MIZEX 84 experiment utilized seven ships, eight remote sensing/meteorological aircraft and four helicopters, supporting a multidisciplinary team of over 200 scientists and technicians plus ship and aircraft crews. Scientists, equipment and support came from Canada, Denmark, Federal Republic of Germany, Finland, France, Ireland, Norway, Sweden, United Kingdom and United States. Figure 1 presents the MIZEX 84 platform and field organization. Figure 2 summarizes the participation for each platform.

The detailed schedule of operations for carrying out the MIZEX 84 experiment was developed by the MIZEX Science Group over the past two years. Building on the MIZEX 83 experience, the operations plan with integrated schedule for all major programs was completed as planned with only minor field modifications necessary. Figure 3 summarizes the MIZEX 84 experiment. Information on the individual MIZEX 84 project is presented by the Principal Investigators preliminary reports contained in this volume.

In preparation for the MIZEX 84 field operations, analysis of satellite imagery was begun in Bergen on 1. May 1984. These data, coupled with the ice reconnaissance flight by the Greenland Ice Patrol, provided the necessary information to select the final sites for instrumentation deployment.

USNS LYNCH began operations on 18 May 1984 by deploying an array of current meters and an acoustic source in the open water areas of the Fram Strait. An initial, open water CTD transect was also completed during the first leg cruise by LYNCH.

POLARQUEEN was on station with all instrumentation deployed to start the Drift Program on 8 June as scheduled. Wind and current drift carried her to the ice edge and floe breakup forced a redeployment to the northwest on 17 June where she drifted, moored to the same floe until the termination of the drift experiment on 17 July.

Two synoptic CTD oceanographic mappings were completed. These included extensive biological investigations. Mesoscale oceanographic investigations

along the ice edge included repeated studies of eddy features identified by the synoptic mappings and remote sensing overflights. The ability to receive near real-time displays of mesoscale ice and water features from both aircraft and satellite permitted the Field Coordination Team to prescribe ship and aircraft investigation patterns. Three largescale CTD transects, including biological and ice stations, were completed across the Fram Strait.

The five-day synoptic meteorological experiment, 9 to 14 July, was an intensive study across the marginal ice zone. Four ships and several aircraft participated in this experiment.

Ice dynamics and ice physics studies were carried out by several coordinated and complementary projects aboard. POLARQUEEN, POLARSTERN and KVITBJØRN including extensive tracking of an array of ARGOS drifting oceanographic-meteorological buoys and transponders. Near real-time analysis of these observations was also utilized in directing the experiment. Ocean current information was obtained by sub-surface drifters acoustically tracked (SOFAR), surface ARGOS buoys, CODAR, and current meters both anchored and suspended from ice floes.

Extensive passive-active microwave remote sensing investigations were carried out both by aircraft and in-situ platforms (see Figure 4). The observations provide synoptic characterizations of the marginal ice zone.

The acoustic program conducted, primarily from the Kvitbjørn with vital support from LYNCH, POLARQUEEN, SVERDRUP and P-3 aircraft from Norway and USA, was carried out essentially in a single deployment between 9 and 29 June. Some adjustment of the arrays were necessary near the end of the period as the ice drift carried them near the edge where floe breakup began.

Modelers will utilize the data from many experiments to improve predictions of the motion and behavior of the Arctic marginal ice.

Fortunately, during the MIZEX 84 experiment, several low pressure systems passed through the region. This resulted in variable wind conditions with velocities ranging from 0 to 15 m/sec.

During June and early July flying weather was exceptionally good and helicopters were able to fly to the limit of pilot times. In early June, one POLARQUEEN helicopter had an engine failure while sitting on the ice. The replacement engine was flown to the field, replaced and the helo was operational in just three days with only minor impact on project activities. One POLARSTERN helicopter suffered a rotor frame failure near the end of the operations. This terminated the French low level scatterometer study of the ice surface. From the second week of July, fog prevailed thus limiting use of helicopters.

Ice floe ridging near POLARQUEEN caught one Bergen met-ocean buoy resulting in the loss of a string of six current meters and over a month of important data. However, one cyclesonde nearby was recovered by a diving team, SVERDRUP's experiment was terminated one day early due to an instrument cable being damaged by a Russian ship.

Communications, usually difficult in such remote regions, proved to be effective during MIZEX 84 in comparison to MIZEX 83 operations. The communication plan, set forth in the Operations Plan, was modified twice to simplify procedures and to minimize time spent in radio communication among ships and with shore coordination points. The use of telex and telefax were effective in reducing voice radio and for the relay of both data and figures. The ability to use satellite telephone and telefax at high latitudes, up to about 80N, was and unexpected bonus for effective communications. While more expemsive than radio, it did not interfer with instruments or data taking.

The Tromsø Coordination Center was effective in scheduling aircraft operations; in monitoring and relaying ARGOS buoy positions, near real-time remote sensing analysis, weather forecasts, and ice conditions; and in a variety of logistic activities. High quality weather forecast were also provided by the German meteorological office aboard POLARSTERN.

Completing essentially all the planned work as scheduled, every participant contributed substantially to the success of the MIZEX 84 field operation. The combination and integration of these results should prove to be an important advance in our understanding of the Arctic marginal ice zone.

MIZEX 84 FIELD ORGANIZATION

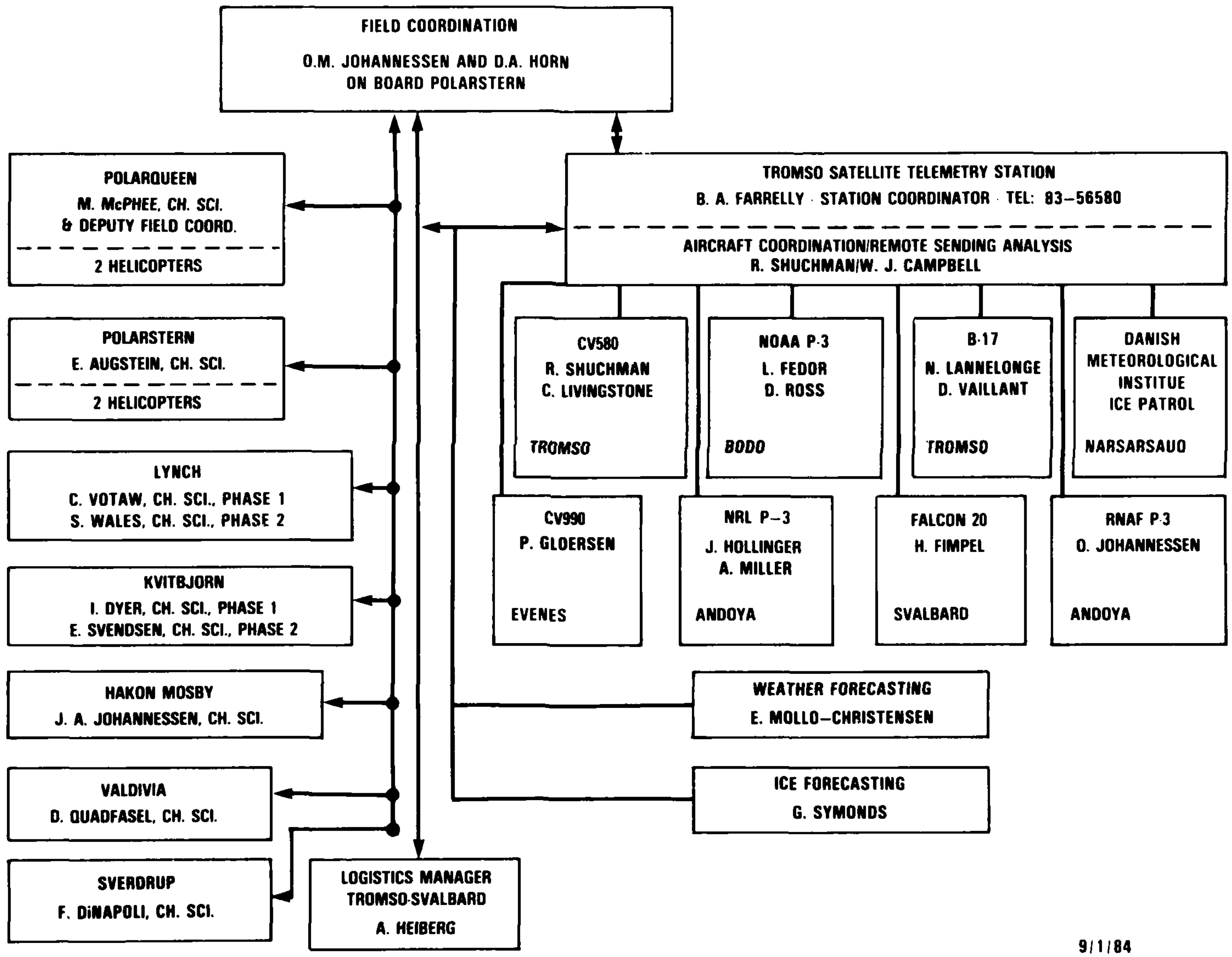


FIG. 1

MIZEX 84

FIELD OPERATIONS: MAY 18—JULY 30, 1984

SHIPS:

USNS LYNCH	(NRL)	MAY 18 – JUNE 28
HU SVERDRUP	(NDRE)	JUNE 1 – JUNE 25
MV POLARQUEEN*	(PSC)	MAY 29 – JULY 29
MV KVITBJORN	(PSC)	MAY 30 – JULY 30
MS HAKON MOSBY	(U. BERGEN)	JUNE 12 – JULY 15
FS POLARSTERN*	(A.W.I.)	JUNE 11 – JULY 18
FS VALDIVIA	(U. HAMB.)	JUNE 20 – July 18

*2 HELICOPTERS ON EACH SHIP

AIRCRAFT:

CCRS CV 580	(CANADA)	JUNE 26 – JULY 8	(8 FLTS)
CNES B–17	(FRANCE)	JUNE 30 – JULY 16	(6 FLTS)
NASA CV 990	(USA)	JUNE 8 – JUNE 30	(7 FLTS)
NOAA P–3	(USA)	JUNE 20 – JULY 7	(6 FLTS)
NRL P–3	(USA)	JUNE 24 – JULY 8	(7 FLTS)
GREENLAND ICE PATROL	(DENMARK)	MAY 29 – (1 FLT)	
RNAF P–3	(NORWAY)	JUNE 11 – JULY 18	(6 FLTS)
DFVLR FALCON	(GERMANY)	JUNE 22 – JULY 14	(20 FLTS)

MIZEX PERSONNEL (FROM 10 NATIONS):

SHIPS	164
AIRCRAFT	36
SHORE SUPPORT	18
TOTAL	208

FIG. 2

MIZEX 84 PROGRAM OVERVIEW

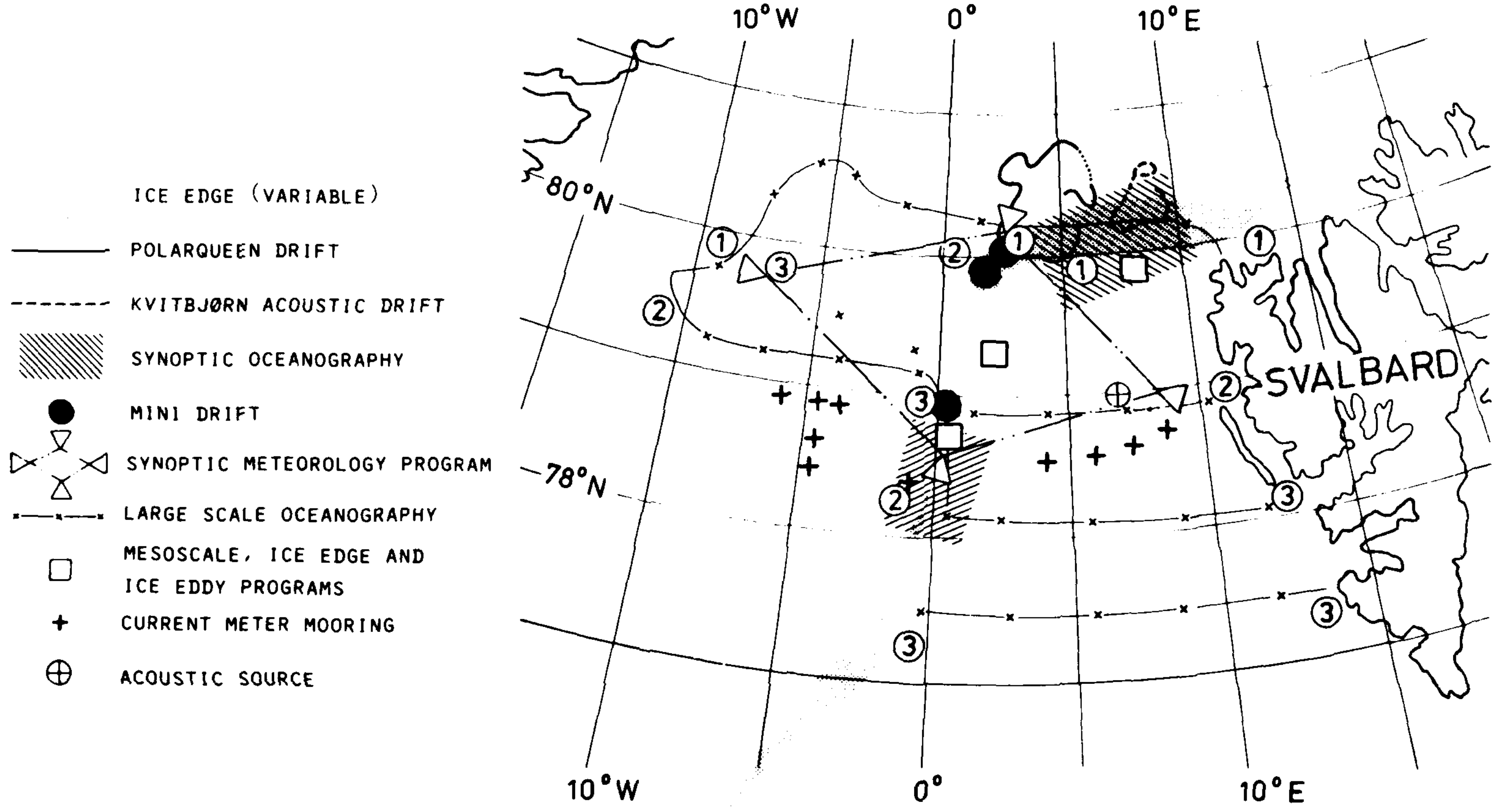
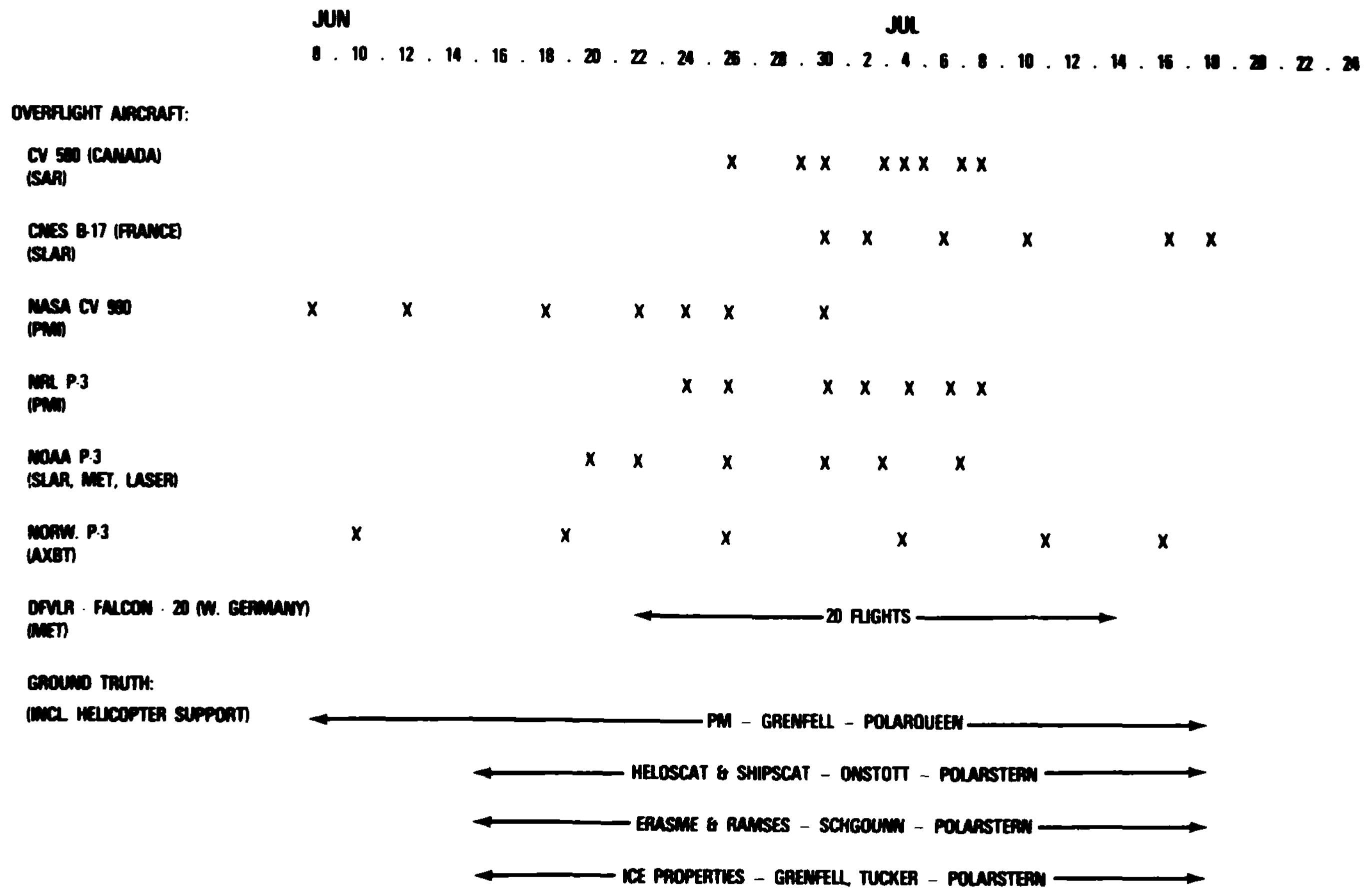


Fig. 3



MIZEX 84 AIRCRAFT OPERATIONS FOR REMOTE SENSING AND METEOROLOGY

Fig. 4

MIZEX CO-ORDINATION TROMSØ

Brian Farrelly
Bergen MIZEX Group*, Geophysical Institute, University of Bergen, Norway

In Tromsø MIZEX activity was concentrated at the MIZEX Coordination Center at Tromsø Satellite Telemetry Station. This center had four primary tasks: communication, buoy tracking, flight coordination and logistics. The center was manned by Brian Farrelly, Graham Symonds, Bob Shuchman and Imants Versnieks.

Communications were based to a large extent on the use of telex for the transmission of daily routine messages to the ships. These messages included typically

1) weather forecast prepared at the Weather Forecasting Center for Northern Norway,
2) report on aircraft activities,
3) aircraft plans for next day,
4) ice edge information either using satellite images from Tromsø Satellite Telemetry Station and SMMR Nimbus 7 "real time" map, or based on telexes from Navoceano,
5) edited telemail or other messages to experimenters in the field.
6) Argos buoy positions.

After problems with long telexes buoy positions were sent separately.

The telexes were prepared on an Osborne I microcomputer and transmitted to Rogaland Radio for retransmission to the ships. The conversion to telex code used a Hasler telex unit. After familiarisation with the equipment the setup worked well. It is understood that the ships at times had problems reaching Rogaland Radio to send and receive telex.

Telefax using satellite telephone was used to and from Polarstern for

1) routine morning reports,
2) sketchmaps of SAR and SLAR results,
3) SMMR ice charts based either on telemail from NASA Goddard Space Flight Center or telefaxed maps from AES Associates, Canada.
4) AXBT charts based on results from Norwegian P3 flights.

The telefax link to Polarqueen over Svalbard Radio was tested successfully but not used routinely.

Telephone over Svalbard radio was used much less than in 1983 and only for nonroutine traffic. Satellite telephone on Polarstern and Lynch worked extremely well and was usable to much higher latitudes than in 1983. Though this link is expensive the high quality enables traffic to be handled quickly without repetition.

Graham Symonds kept track of the Argos buoys using an Osborne Executive to access the telex files of System Argos in Toulouse via the Norwegian packet sentre network Datapak. This was done twice daily and the resulting

*Bergen MIZEX Group: O.M. Johannessen, J.A. Johannessen, E. Svendsen, B. Farrelly, S. Sandven, T. Olaussen, S. Myking and A. Revheim.

diskettes were processed to reduce the data to a format suitable for transmission to the ships. Twelve hour mean positions were also calculated and plotted on a large scale chart to obtain an overview of ice motion. The task was time consuming and would have been impossible without the computer.

The Argos system was also accessed outside the routine times when necessary for buoy recovery etc. Buoy positions calculated using K. Aksnes (Norwegian Defence Research Establishment) algorithm in Tromsø were also used for near real time (within/hour) updating. The Tromsø positions are now considerably more reliable than in 1983 owing to improvements in the algorithm.

Wheras in 1983 southerly winds dominated and much of the ice motion was easterly or northeasterly, northerly winds were experienced in 1984 leading to southwards motion of the ice, with less coherence in the motion north of 80°N than in 1983. Further south the motion of the buoys showed the influence of eddies in the EGC and will be a valuable addition to CTD measurements. For more details see PI report from Graham Symonds and Ola M. Johannessen.

Bob Shuchman had primary responsibility for aircraft coordination. The scientific objective of this coordination was to ensure that overflights by remote sensing aircraft were supported by surface measurements, to achieve near simultaneous coverage by instruments requiring intercomparison, and to obtain optimal spatial and temporal coverage of the MIZ. The coordination also involved the safety aspects of ensueing adequate lateral, vertical and temporal separation of aircraft.

Logistics were the primary responsibility of Imants Versnieks.

Finally an aspect of the coordination in Tromsø was contact with the Weather Forecasting Center for Northern Norway This was not improved over the 1983 level. In addition the computer setup which was to be used for SMMR maps and digitising of weather charts at the Weather Forecasting Center for Northern Norway did not work satisfactorily.

OCEANOGRAPHY

OVERVIEW ON "POLARSTERN'S" ACTIVITIES

Prof. Dr. Ernst Augstein

MIZEX was carried out during the second leg of "Polarstern's" 1984 cruise Arktis II. On 12 June 1984 at 19.00 LT "Polarstern" left the port of Tromsö with 55 scientists and technicians and 40 crew members on board.

The first task was to deploy five and to recover two deep sea current meter moorings in the sea ice covered ocean east of Greenland at about 79°N. This work started on 14 June and was finished on 17 June. Both positions of the current meter moorings to be recovered were covered by large ice floes. Since the mooring devices did not respond to the acoustic control the command for realease was given with some uncertainty. The first one floated up in a small lead near the given position while the second one either did not react at all or was captured under the ice. The mooring work was complemented by CTD measurements, sea ice probing, biological and chemical analyses and meteorological soundings.

On the way from the mooring site to the north" Polarstern" had a short rendezvous with " Hakon Mosby" in order to exchange scientific gear. Both ships performed subsequently measurements within a so called synoptic grid accross the zonally oriented ice edge near 80°N. During this work "Polarstern" furthermore recovered and redeployed two meteorological-oceanographic buoy stations of the University of Bergen. Finally, the three meteorological buoys of the University of Hamburg were deployed by helicopter.

The synoptic CTD grid consisted of open water measurements by "Hakon Mosby" and stations in the ice conducted by "Polarstern" and helicopters. The extensive oceanographic survey was accompanied by biological samplings, chemical analyses, meteorlogical investigations, ice probing and remote sensing studies from the ship and by helicopters. Because of heavy ice conditions the synoptic work was extended to 22 June 09.00 GMT.

The following period from 22 to 25 June was primarily devoted to study the kinematics of the ice edge region in the area of the first synoptic survey. A total of 10 transponders was distributed on ice floes by helicopters and tracked with the ship's radar. Seven transponders could be recovered, one was destroyed and two could not be located. At the end of the minidrift station " Polarstern" met with the University of Hamburg's RV "Valdivia" near the ice edge in open water in order to assist in calibrating the current measuring device CODAR.

When this procedure was finished both German ships started a

large scale oceanographic survey across Fram Strait. "Valdivia" was responsible for the open water part while "Polarstern" extended the first transect on 80°20'N through the sea ice westwards to the East Greenland Shelf. A second transect was executed on the latitude of 79°20'N. Heavy ice conditions forced an extension of this work by nearly one day so that the beginning of the second minidrift had to be postponed until 06.00 GMT on 3 July.

Due to this delay the full array of seven transponders and one reflector was operational not before the afternoon of 3 July. On 4 July equipment and personnel of the Scott Polar Research Institute was transferred to the RV "Kvitbjörn" in order to continue the transponder tracking from that platform. Three of the four Alfred Wegener Institute transponders have been retrieved before "Polarstern" left the area on 4 July. During this experimental period some personnel was transferred from and to Longyearbyen.

For the second synoptic array "Polarstern" had to sail to 78°25'N and 01°W. The survey was again carried out jointly with "Hakon Mosby" and "Valdivia". It ended at noon on 8 July when " Polarstern" departed the area for the position further northwest which she had to occupy during the meteorological large scale network.

This position near 79°40'N and 6°30'W was kept from 9 to 14 July 1984. Because of the relatively small water depth on the Greenland Shelf only reduced oceanographic and biological measurements have been conducted. Helicopter work was also considerably limited since one aircraft was unservicable. Additionally, poor visibility caused by fog forced the other helicopter also down for most of the time.The large scale meteorological programme was terminated on 14 July 12.00 GMT.

"Polarstern" then moved first eastwards to about 79°45'N 2°30'W and from there southeastwards to 79°N 00°30'E. On the entire leg a total of 11 oceanographic stations some of which were extended for biological sampling have been carried out. The final observational contribution to MIZEX was a meridional cross-section from 79°N to 78°20'N on the Greenwich meridian. The oceanographic and biological measurements on this transect will help to describe a relatively large eddy-like feature at the ice edge.

The ship departed from the experimental area on 17 July 16.00 GMT for Longyearbyen/Svalbard where it arrived on 18 July 12.00 GMT. With the exeption of three persons all scientists and technicians disembarked during the afternoon of the same day.

PI REPORT, CTD GROUP, POLARSTERN

K.P.Koltermann, DHI, Hamburg

During MIZEX 84, Polarstern did 131 CTD casts, with ca. 1200 samples for nutrients, oxygen and salt. Most CTD casts were run to the bottom, only 31 were down to 600 m. All standard chemical analyses were run on board. The CTD was 0.016+/-0.003 to high compared to the salinity samples run by P.Jones (FIO).

The stations worked during the cruise leg can be grouped into different subsets :

- a minigrid SSW of the Yermak Plateau
- a drift station E of the Yermak Plateau with 25 hourly casts
- five sections onto the Greenland Shelf along

  78 25 N, 79 00 N, 79 20 N, 79 50 N and 80 20 N

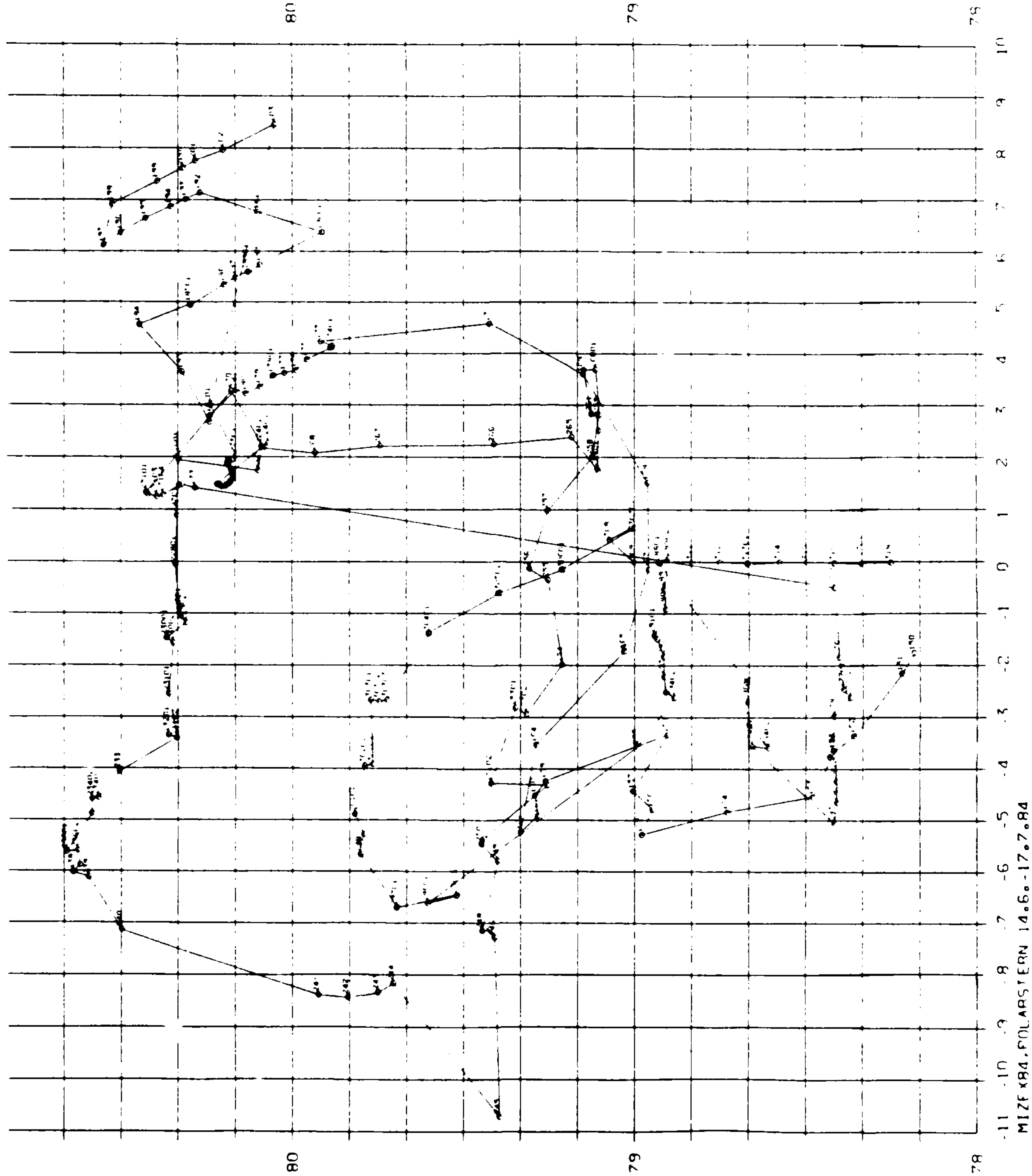
- one NS section along the Greenwich meridian between 79 and 78 N with a 5 nm spacing.

Except for five casts, all were done in the ice.

The surface layers show strong features both horizontally and vertically ; most can only be taken as meandering of the different water masses in or off the ice edge.Only the Molloy Deep Eddy is persistent during the whole cruise. More detailed aspects can only be discussed after merging the different CTD data sets. The strongestv variations are confined to the top 150 m. The underlying Atlantic Water shows strong variations both in thickness, number of extrema and core temperatures, indicating especially east of the prime meridian strong mixing.

Along the Greenland Shelf the physical fields are much smoother and vary mainly in EW direction. Here on the 1800 m isobath a very strong silicate maximum in the surface layer is found, being evidence that the same feature observed in the Arctic,leaves at the west side of Fram Strait. Below the Arctic Intermediate Water on the 2200 m isobath and at ca 1600 m depth a secondary silicate maximum with higher salinities and temperatures suggests another deep outflow from the Arctic, as also clearly shown in the Meteor data in 1982.

The Deep Water shows in Fram Strait rather strong horizontal changes both in salinity, oxygen and temperature, implying that within Fram Strait strong mixing of waters of Arctic and Polar origin occurs even at depth. Following individual properties in respect to changes in topography one clearly notes that all topographical changes are reflected in the flow field at all depths. This strongly barotropic behaviour of the main circulation and the first order variations have a significant influence on the distribution of properties near or at the surface.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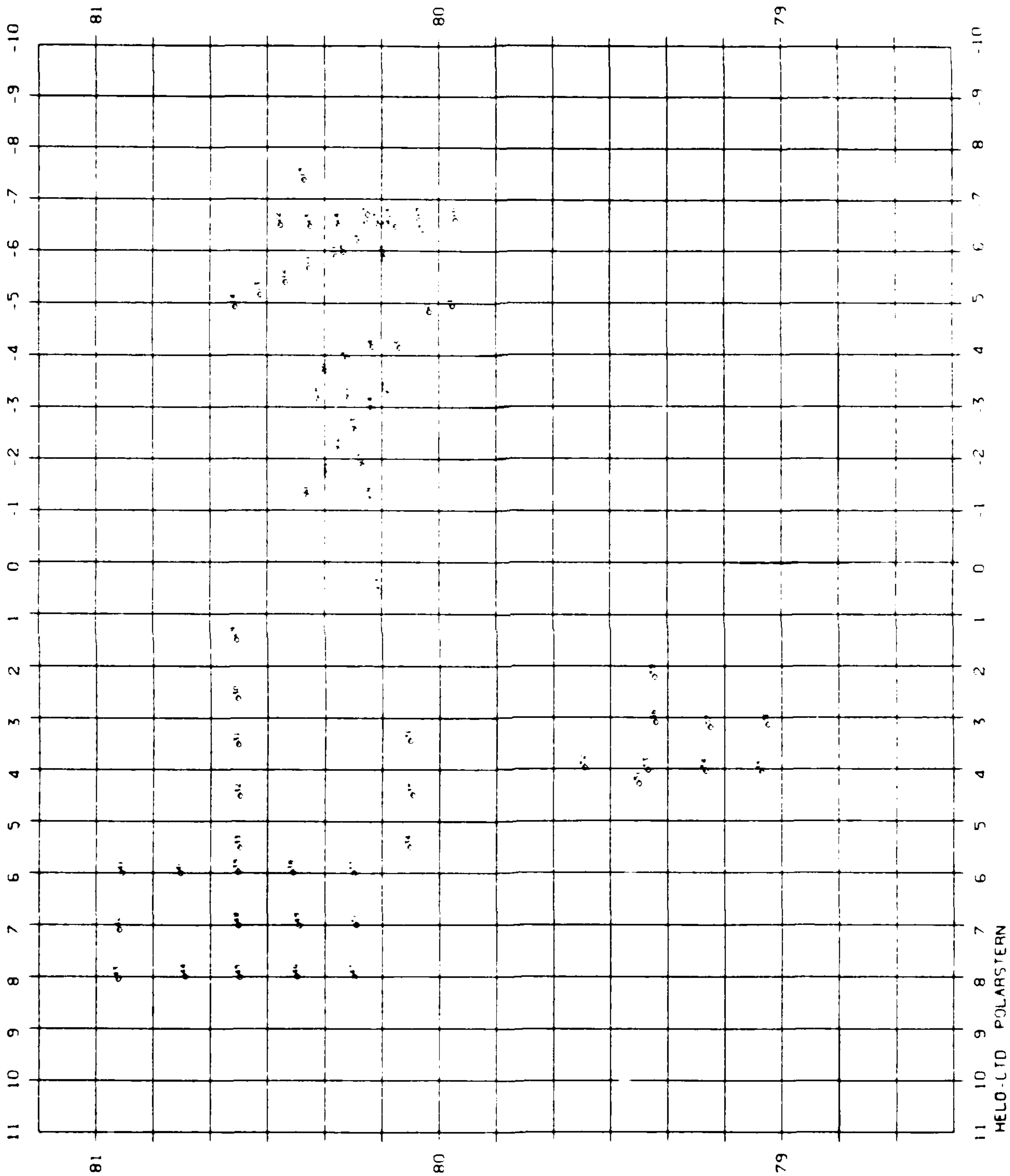
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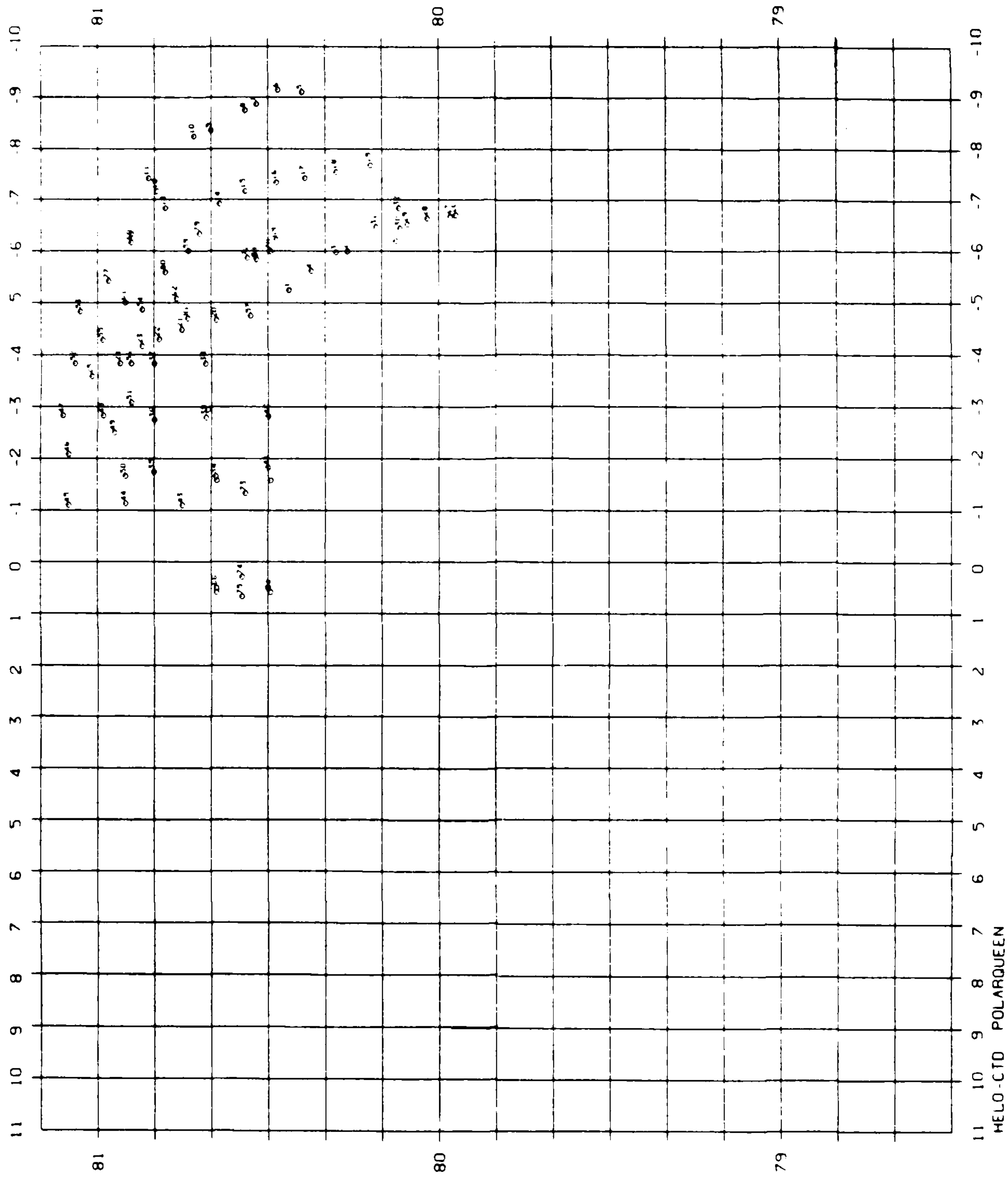
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LAMONT CRUISE REPORT - MIZEX 84

Thomas Manley

Lamont field operations were conducted from the USNS LYNCH, the M/V POLARQUEEN and the F/S POLARSTERN. During the May 18 to May 31 LYNCH cruise, a year-long mooring was recovered and one short term mooring was deployed. Both of the current meters in the long-term mooring succesfully recorded data over the complete period of 340 days at depths of 90 and 190 meters. A 15-station CTD transect was also completed from the ice edge onto the Svalbard shelf at a latitude of 78 deg. 55 min. On the second leg of the LYNCH (5-22 June), which was primarily acoustics, a total of 11 additional CTD stations were taken during various cooperative ship programs pertaining to MIZEX 84.

The helicopter-based CTD program was split between the POLARSTERN and the POLARQUEEN. Observations commenced on the 14th of June and were concluded on the 17th of July. A total of 222 stations were taken during this time period, ranging in depth from 100 to 650 meters, and as far away from the ship as 50 nm. Of these, 208 were helicopter-based, and 14 provided inter-calibration statistics with the shipboard Neil-Browns.

Spatially, a majority of the helicopter-based CTD stations were confined within the limits of 80 to 81 north latitude and 8 W to 10 E. Stations outside this area were obtained primarily from the POLARSTERN in the region from 79 N to 80 N and 2 W to 6 W in order to better define the East Greenland front. Stations were normally grouped into single-day surveys designed to accurately, as well as rapidly, map three-dimensional oceanic structures from the extreme edges of the MIZ to the more centrally ice-covered regions. Patterns and interstation spacing varied depending on the involvment of open water, the proximity of ships doing CTD surveys to the ice edge, and the type of feature being mapped. Most of these single-day surveys consisted of four to ten stations set in either a linear or box pattern with an average separation of 6 nm. Typical spatial average for a box survey was 150 sq.nm (depth of 600 m), while the largest 10-hour survey accomplished to date consisted of 14 stations and covered some 800 sq.nm.

Prior to completion of the field project, the short -term mooring previously deployed by the LYNCH was retrieved by the POLARQUEEN with all meters functioning.

Over 60% of the helo-CTD data collected were devoted to cooperative mapping efforts with ship-based CTD's. Due to the dispersed nature of the data sets, it is virtually impossible to come up with explicit results. One survey, (which was predominantly helo-CTD oriented), however, did tend to indicate an intrusive tongue of warm saline water interior to the ice-edge front.

LONG-TERM CURRENT MOORINGS IN THE EAST GREENLAND CURRENT - EAST GREENLAND POLAR FRONT SYSTEM

Robin D. Muench

Two long-term, over-winter current moorings were deployed approximately along the 1000 m isobath on the continental slope beneath the East Greenland Current - East Greenland Polar Front system in mid-June 1984, early during the MIZEX East field program. Particulars, such as geographical coordinates, dates and water depths, are given in the below table. The moorings were deployed from the vessel POLARSTERN by Mr. Clark Darnall of the University of Washington (UW); no problems were encountered during deployment. The "standard" oceanographic taut-wire configuration was used. It is planned to recover the moorings sometime in summer 1985.

The MIZEX long-term moorings were deployed at the same time as a larger scale array across Fram Strait; the Fram Strait array was deployed as a part of Dr. K. Aagaard's (UW) program. At least three of the UW moorings will be used in conjunction with the MIZEX moorings to examine the mesoscale dynamics of the East Greenland Current - East Greenland Polar Front system. Approximate locations for the MIZEX and three of the UW moorings are shown, along with the local bathymetry, on the appended figure. Like the MIZEX moorings, the UW moorings will be recovered in summer 1985.

Particulars for the MIZEX over-winter current moorings

Mooring ID	Lat. (N)	Long. (W)	Deploy Date (Z)	Deploy Hour (Z)	Bottom Depth (m)*	Instrument Depths (m)*
MX-1	78°43.988'	4°51.131'	6/15/84	0846	994	94** 394**
MX-2	78°29.160'	4°33.288'	6/15/84	0130	1020	120** 420**

*Depths have been corrected for sound velocity variation.
**Instruments were Aanderaa RCM-4 recording current meters.

LONG-TERM CURRENT MOORINGS IN THE EAST GREENLAND CURRENT - EAST GREENLAND POLAR FRONT SYSTEM

Robin D. Muench

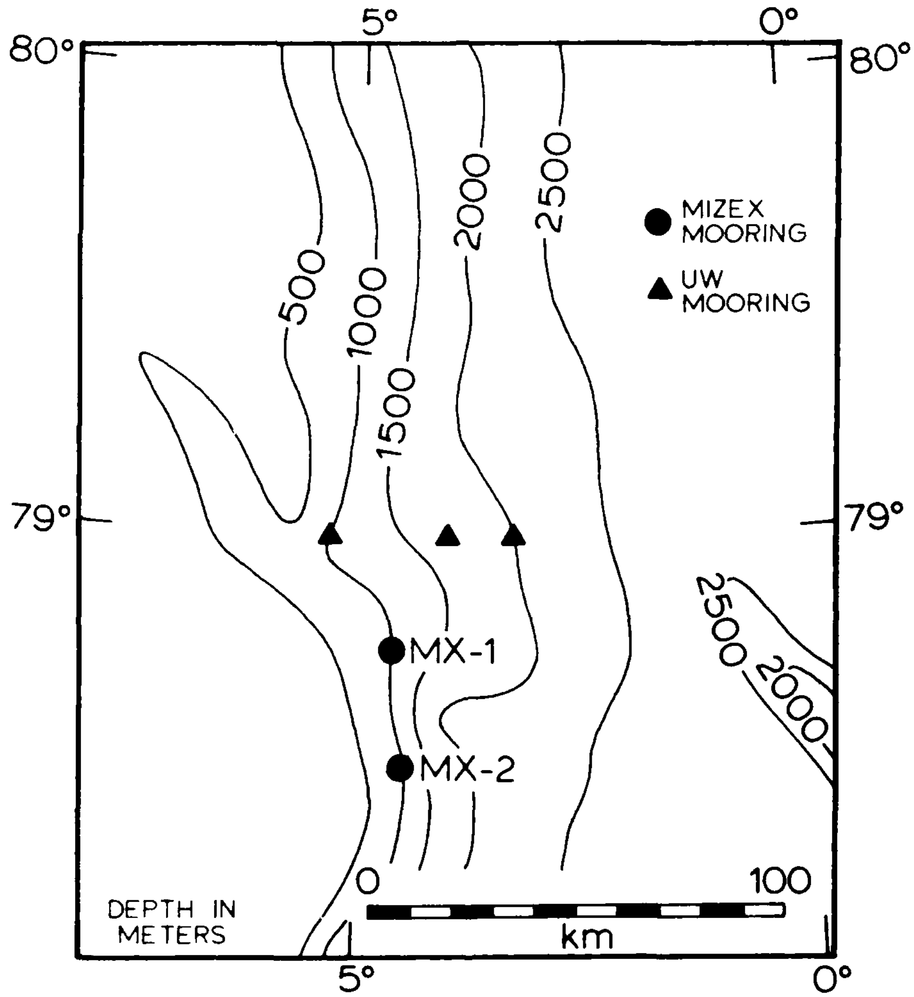


Figure illustrating schematically the geographical locations of the MIZEX long-term current moorings, three of the University of Washington (UW) moorings and the local bathymetry.

Chemical Oceanography in the Greenland Sea

E.P. Jones and L.G. Anderson

The goals of the chemical oceanography program on board F.S. Polarstern during MIZEX 84 were: (i) to examine the chemical composition of sea ice, (ii) to look for changes in the chemical constituents of near surface water as a result of the addition of sea ice meltwater and the presence of sea ice, and (iii) to examine several chemical constituents of seawater for water mass identification and tracing.

In sea ice produced in the laboratory, the relative composition of salts in the brine entrained in the ice changes as a result of the selective precipitation of the salts from the brine when the ice is cooled. Calcium carbonate is the first to precipitate, beginning to do so just below the freezing point near -2°C, followed by sodium sulphate near -10°C. Almost no studies have been done to verify the laboratory results and their geophysical implications using sea ice produced under natural conditions. Several cores of first year and multi-year ice were collected throughout the MIZEX area. Not one showed anything like the degree of relative calcium enrichment expected on the basis of the laboratory results. Sulphate concentrations have not yet been determined, but based on the calcium data, little sulphate enrichment is expected. These results seem to show that the studies of ice produced under laboratory conditions cannot be used in any simple way to describe the composition of natural sea ice.

The examination of near surface water to determine changes in composition resulting from the addition of sea ice meltwater involved measurements of calcium, alkalinity, and O^{18}/O^{16} isotope ratios. Preliminary results show essentially no change in either calcium or alkalinity attributable to the presence of sea ice meltwater. Oxygen isotope ratios are expected to determine how much of the freshwater component of the surface water is from river input and how much is from sea ice meltwater.

Preliminary examination of the chemical data shows no obvious ice edge effects such as upwelling attributable to the physical presence of sea ice. Definite conclusions, however, will have to await a more thorough examination of the data.

Water mass identification and tracing involves examination of salinity and temperature distributions together with chemical components such as nutrients (measured by the University of Hamburg Chemistry Group), calcium, alkalinity, inorganic carbon, oxygen, and pH. The chemical components are used both individually and in combination (e.g., nitrate and oxygen to form the tracer "NO") to determine circulation and mixing of water masses. The exploitation of these measurements will take considerable effort on the part of all groups contributing to the data. One preliminary result immediately apparent, however, is the presence of water from the near surface halocline of the Arctic Ocean identified by a nutrient and inorganic carbon maximum. This water in the East Greenland Current seems to have maintained much of its identity along the Trans Polar Drift current and out of the Arctic Ocean

through Fram Strait.

Altogether, approximately 1500 samples from 90 stations were analyzed for oxygen and salinity, and approximately 800 samples from 50 stations for alkalinity, inorganic carbon, calcium, and pH. About 540 samples from 60 stations were collected for oxygen isotope ratio determinations. Eight ice cores, four first year and four multi-year, sectioned into 20 cm lengths, were analyzed for salinity, calcium, and alkalinity. About 140 samples from 7 stations along the 82^0N transect and 12 samples at the western-most station of the transect were collected respectively for tritium and helium-3 analyses at the University of Miami.

POLAR QUEEN Drift, MIZEX 84

Miles G. McPhee

During the main MIZEX 84 experiment, the **POLAR QUEEN** was designated the primary drift-station vessel, and was allowed to drift passively with surrounding ice, while moored securely to a floe on which various experiments were deployed. The drift occured in two phases: the first, which started about day 159.5 (i.e., noon GMT on 7 Jun 84), was characterized by rapid southward motion in response to northerly winds. It was terminated early on day 168 when ocean swell propagating in from the ice edge, which was by then about 1-2 km distant, broke the camp floe into several pieces.

The ship and its surrounding instrument array were then redeployed about 60 km to the northwest. The second drift station was maintained for about 30 days, with the ship moored to a large floe (approx. 300 x 400 m). Measurement programs were terminated at 00Z on day 200, with the remainder of the experiment occupied by instrument recovery and transit.

Following are plots of navigational data for the **POLAR QUEEN** during its two drifts. Figure 1 shows each SATNAV satellite fix considered acceptable in the algorithm used by the Magnavox satellite navigator for updating its dead reckoning positions: this automatically disqualifies single channel fixes, low angle satellite passes, etc., and appeared to have about the proper selectivity. Acceptable fixes were randomly spaced in time, with typically 35 to 40 available per day. Crosses in the trajectory mark the first good fix of each day. Times of the first and last fixes in each drift segment are listed.

In order to estimate drift velocity, the observed positions were fitted to a mathematical expression for position as a function of time, which was then differentiated. The technique is described in detail by McPhee (Drift Velocity during the Drift-Station Phase of MIZEX 83, MIZEX Bull. #4), and consists of describing the trajectory as a superposition of mean drift plus clockwise and counterclockwise rotating components at two frequencies: inertial (about 12.2 hour period) and diurnal tidal (24 hour period). Six complex coefficients were fitted every three hours from all acceptable fixes in the preceding and succeeding 12 hours. The resulting coefficients were then used to construct an evenly spaced time series of hourly positions, which are plotted in Figure 2. Here each dot represents the position on the hour, with pluses indicating 00Z.

From the fit coefficients it is also possible to construct a times series of drift velocity as shown in Figures 3 and 4. Ordinate scales are cm/s. The designations 'east' and 'north' are approximate, being based on a coordinate system with the y-axis directed north along the Greenwich Meridian (see the positions plots); however, any correction is small, especially during the second drift.

The final plot, Figure 5, shows ship heading as determined by the inertial navigation every half hour, which data are useful for estimating floe rotation. Slop in the ship's mooring was present as mooring lines required adjustment, but was limited to a few degrees.

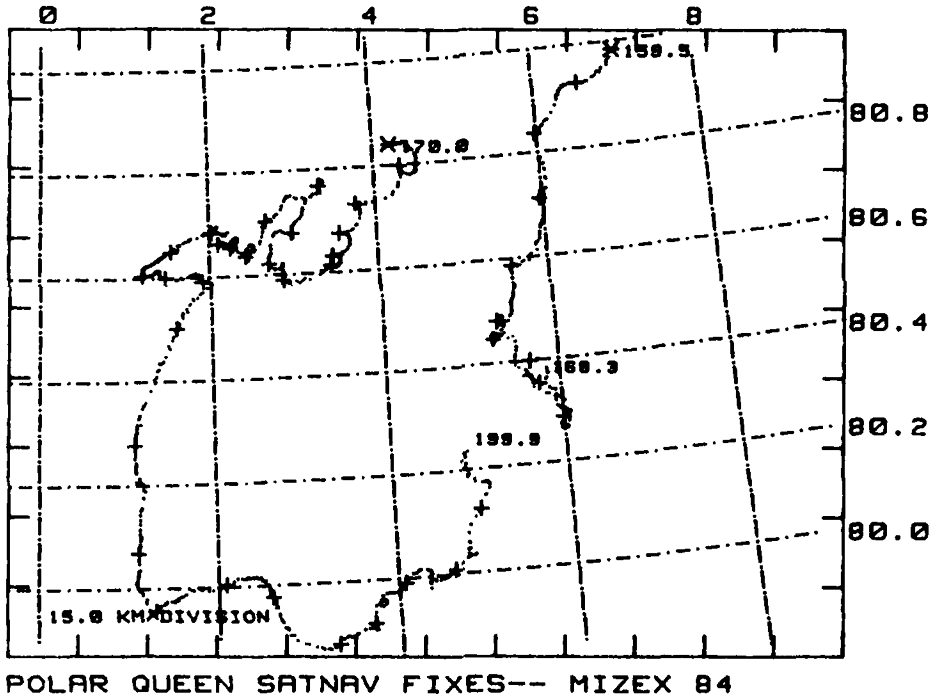


Figure 1.

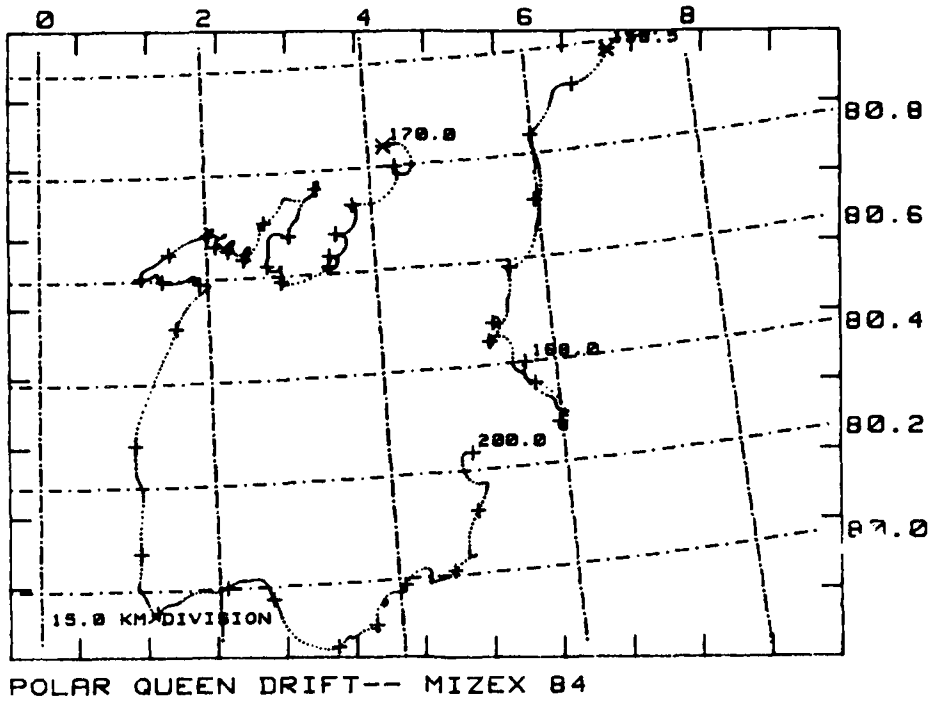
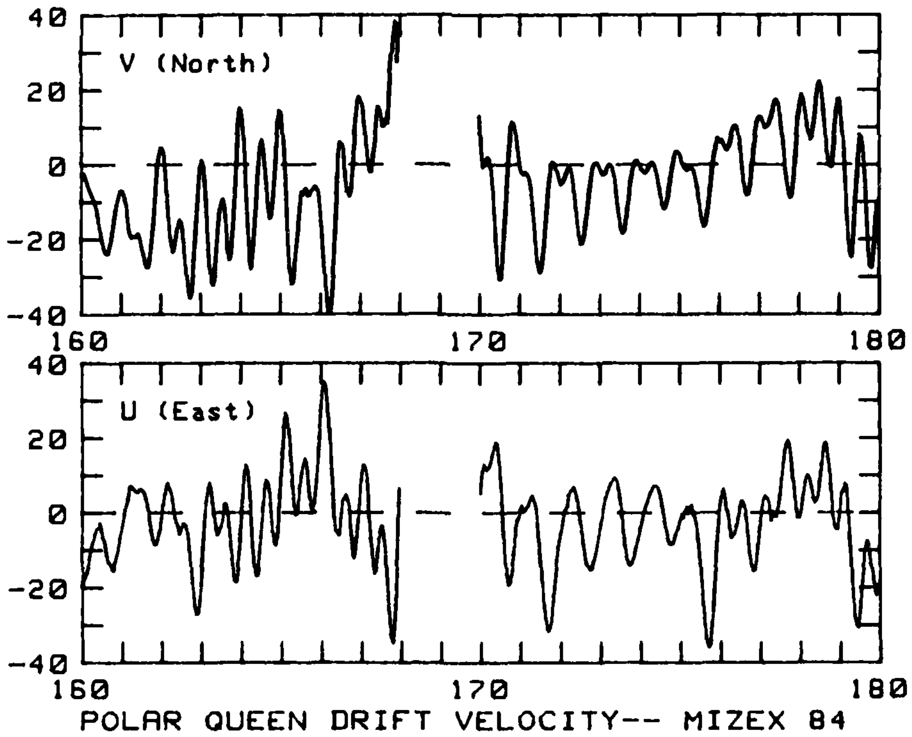


Figure 2.



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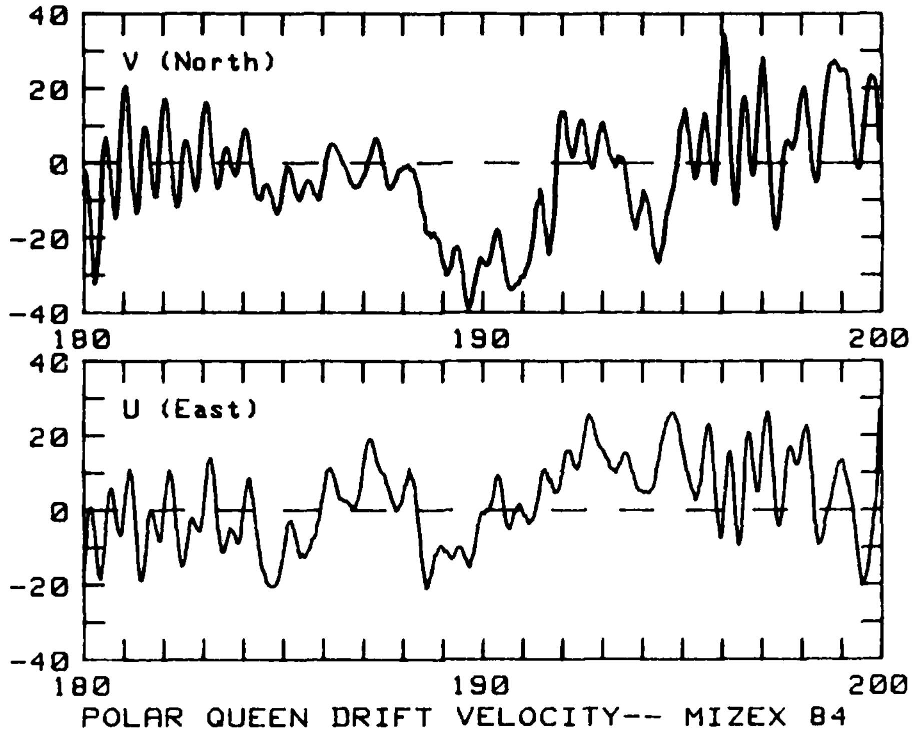

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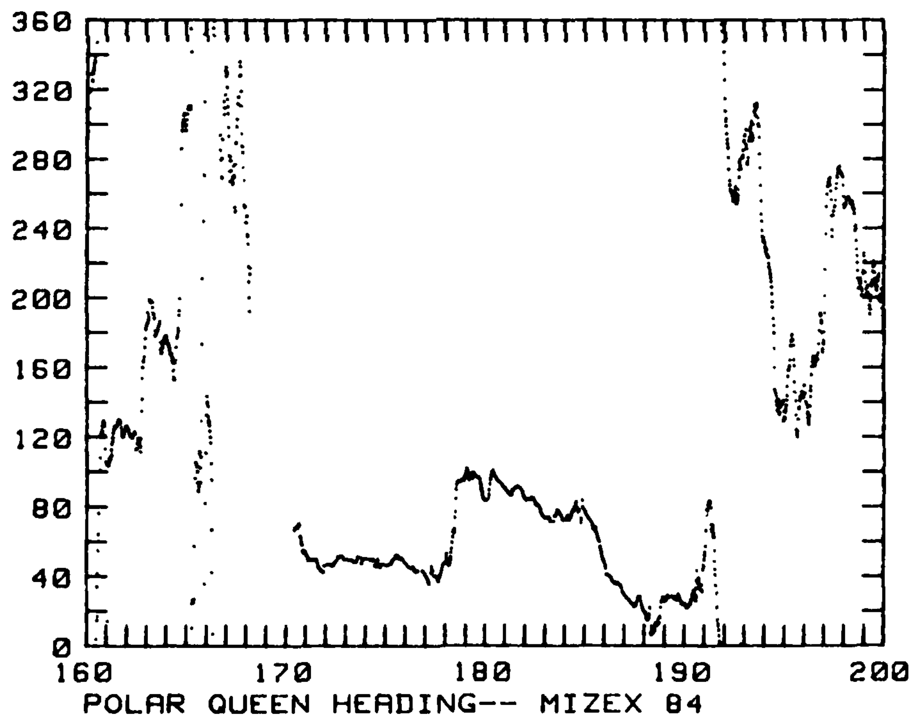


Figure 5.

LAGRANGIAN FLOATS EXPERIMENT

P.I.: J.C. GASCARD

The french program during MIZEX had two components:

- remote-sensing of the marginal ice field using three active radars (Remote-Sensing Laboratory in Toulouse/CNES)
- Lagrangian observations in the Ocean and on the ice (Physical Oceanography Laboratory in Paris CNRS/MUSEUM).

We report here on the second part of this program: Lagrangian observations, the purpose of which was to map the oceanic currents (mainly the Atlantic current) at surface and at depth and the sea ice motions to get informations about variability and mean component of motions and their dependance on atmospheric forcing, bottom topography, frontal structures (3D), ...

Three types of floats and buoys were launched depending on their use at surface or at depth:

at depth: 10 acoustic floats like SOFAR floats. They are freely drifting Swallow floats ballasted in order to be neutrally buoyant at preselected depths : 4 floats stabilized around 110 to 130 m depth and 6 around 200 to 260 m. The 10 floats were launched from the POLARQUEEN (ship or helo) between 80°14.4N - 80°43.5N and 3°30E - 6°05.5E from June 10 until June 20. Each float, equipped with a 1562 Hz transducer, sent a pulse every hour for tracking and was telemetering temperature and pressure in situ once every second day. Five listening stations received floats signals, and floats locations were computed by considering time of arrival and position of listening stations. Three stations were operating in real time from three different ships: POLARQUEEN, POLARSTERN and KVITBJORN, and two autonomous listening stations, F1 and F2, were deployed, at 700 m depth, from ice floes tagged with Argos buoys and tracked by satellite. Later on (post-MIZEX cruises), two listening stations were mounted first on POLARSTERN (late July-early August) and later on LANCE (late August) extending the float tracking over a one month period in addition to the 50 days MIZEX period.

As a preliminary result, we can tell that we have been able to map some features of Atlantic currents in the Fram Straits, below the ice, during this summer 84 season: four features are already appearing related to the branching of the northward Atlantic current towards the southward East Greenland current:

- northward Atlantic current flowing along the continental slope West of Yermak plateau and entering in the Arctic basin.
- strong topographic features above Yermak plateau: one float has been trapped during the whole MIZEX Experiment above the 500 m isobaths Northwest of Svalbard.
- recirculation of Atlantic waters west of the Yermak plateau along the continental slope and in the deepest part of the Straits.
- southward flowing Atlantic current trapped in the East Greenland current.

In addition to this experiment, we launched three VCMs (Vertical Current Meter) from the H. MOSBY close to the ice edge. Like the other floats, properly ballasted, they become neutrally buoyant at some depth. They are equipped with vanes around the main axis of the cylinder, 1.5 m high. Then they rotate when drifting according to the vertical component of motion (if any). We had a lot of trouble during this deployment for two reasons: float depth equilibrium and listening equipment too sensitive according to ship noise due to variable pitch. Nevertheless, after quite a bit of work, we succeeded in

deploying two floats, at 200 and 700 m depth, in the Molloy deep area and one further Southwest along the ice edge, at about 78°40N and 1°W. Later on, we were not able to recover the 700 m float because of a failure in the release mechanism. The float at 200 m, equipped with a SOFAR 1562 Hz acoustic (in addition to its proper 5 kHz short range acoustic tranducer) was tracked during 11 days above the Molloy deep. Launched on July 4, 30 miles away from the ice edge, at approximately 79°15N - 3°E, it was recovered on July 15 by the KVITBJORN at about 79°12N - 3°30E, among thick ice floes. During these 11 days, this float described an anticyclonic eddy trajectory with a 10 miles radius of curvature, more or less similar to the one described by the 700 m float. The third VCM, deployed along the ice edge, followed a track parallel to the ice edge during 2 days (July 10 to 12) at a depth around 125 m. It has been drifting Southwest at a mean speed of 20 $cm.s^{-1}$ and was recovered at about 78°35N - 2°W in loose ice.

at surface: Other drifters were deployed, both on the ice (7 drifters) and in the nearby ocean (7 drifters). They used Argos transmitter for location via satellite. Ocean drifters used temperature sensor for measuring sea surface temperature within 0.1°C accuracy. Initially, three of them were deployed in the Ocean, at the end of May from the LYNCH, two above the Molloy deep, at about 79°20N - 3°E, close to the ice edge, and one West of Svalbard, at 79°N - 8°E, in the West Spitzbergen current. This last buoy remained more or less in the same area for almost the whole MIZEX period, going back and forth, North and South, and describing a lot of loops. At the end, it started drifting rapidly northwards and disappeared after passing by the Northwest corner of Svalbard. The two other floats remained in the Molloy deep area but did not last more than two weeks. Early June, 4 buoys were deployed in the Ocean, two from KVITBJORN and two by helos from POLARQUEEN, few miles away from the ice edge. One of these failed rapidly for unknown reasons, two others, deployed from KVITBJORN at 80°20N-7°E and 80°30N-8°E, lasted only few weeks, while the last one is still working after three months. On the average, it has been drifting Southwest along the ice edge from about 79°45N-7°E (July 6) to 74°45N -8°30W (September 18). During the first month, this buoy remained at approximately 79°30N - 5°E, trapped in eddy motions east of the Molloy Deep.

In summary, among the 7 drifters deployed in the Ocean (out of 10), three lasted for few days, two lasted for two weeks and two for respectively 2 and 3 months. We do not know yet the reasons for such a discrepancy. It may be due to a mechanical failure of buoys when banging against ice floes.

Seven Argos drifters were deployed on ice floes, in order to follow the drift of ice stations: C2, C3, F1 and F2, and later on, at a currentmeter station with Bergen toroid, which was recovered by POLARSTERN during post-Mizex. All these Argos buoys deployed on the ice floes worked perfectly during the whole MIZEX period. The recovery of these stations was not that simple and we are quite grateful to the pilots and chief scientists on POLARQUEEN for their patience and great help.

In conclusion, we are generally quite satisfied with our results considering our initial planning. The SOFAR floats program has been accomplished to nearly 100% and we are quite pleased with the offer of our German colleagues on board POLARSTERN and our Norwegian colleagues on board LANCE for extending successfully the float tracking from late July to late August. Due to the range limitation (100 miles) in sound propagation, related mainly to ice coverage and bottom topography, we have not been able to receive all signals from SOFAR floats at each listening station, but since our 5 stations were redundant, we hope to recover most of the data for float tracking computations.

Small and Mesoscale Processes in the Summer Marginal Ice Zone Experiment

Theodore D. Foster

This project concentrated on studying the spacial and temporal behavior of the fine structure in the upper ocean in the marginal ice zone. For this purpose we made serial vertical profiles of temperature and salinity of the upper ocean from near the surface to depths ranging from 50 to 1000 meters depth at time intervals from 3 to 60 minutes using a Neil Brown CTD. In addition, we suspended an array of four Aanderaa current meters with temperature and conductivity sensors from the ice floe to which _Polar Queen_ was moored in the main halocline at a depth of 30 meters. The current meter array was in the form of a triangle with an interior meter slightly off center resulting in horizontal spacings ranging from about 100 to 400 meters. In order to resolve internal waves adequately, the sampling rate was set at one sample per minute resulting in approximately 7-day long sampling periods. Two sets of data were obtained with this configuration. A single set of data was also obtained with the current meters suspended at 10, 40, 70 and 100 meters from the ship adjacent to the CTD winch. In addition, we obtained in cooperation with the Lamont-Doherty and University of Washington groups serial temperature and salinity profiles using CTD casts taken simultaneously at three-minute intervals in a triangular array with spacings from about 100 to 300 meters.

As a service to the people studying the large-scale hydrography of the MIZEX region, we took routine CTD casts from the surface to near the bottom on a daily basis while _Polar Queen_ was moored to the ice floe. In addition, we took special CTD casts with Niskin bottles for the University of Miami chemistry program and a number of special casts to 500 and 1000 meters to supplement the Lamont-Doherty mesoscale helicopter CTD program.

Altogether we obtained 324 CTD profile records, 12 current meter records and 19 time-series of temperature and salinity. Preliminary processing of the current meter tapes is being carried out at Lamont-Doherty Geological Observatory by Dr. Hunkins' group. The CTD tapes will be processed at the University of California, Santa Cruz using a PDP11/34A computer.

Preliminary analysis of CTD profile series and time series of temperature and salinity at fixed depths has shown that the principal internal wave activity was in the halocline at about 30 meters depth at a period of about 7 minutes.

Cyclesonde Measurements in MIZEX 84

Dr. John C. Van Leer (University of Miami)

An array of Cyclesondes were deployed in the Fram Straits from the Polar Queen during the MIZEX summer experiment during June and July 1984. These instruments were launched from ice floes over the side using timber "A" frames and a portable motor driven winch. The floe drift was recorded by service ARGOS with French and Norwegian packages which determine the position and provide reference velocity. Instruments and mooring gear were transported by helicopter to floes 5-10km from the Polar Queen. Data were recorded directly in each Cyclesonde on magnetic tape and telemetered by radio to the ship and recorded by HP-86 on magnetic disc. Cyclesondes were also deployed from the same floe to which the Polar Queen was moored given by the A & B sites in the table. The Cyclesondes recorded profiles of temperature, salinity, pressure, current speed, and direction. Profiles were carried out at preset intervals of 1/2 hour, 1 hour or every two hours. Most data were sampled at 30 second intervals giving about three meter vertical resolution. Some data were recorded at 10 second and 5 second intervals for intensive periods increasing vertical resolution to 1 meter and 1/2 meter respectively. A summary of cyclesonde data appears in the table below including an estimated 1,150 total profiles.

Instrument #71 was suspended from floe C1 when it was transformed into a pressure ridge on the 3rd of July. It was recovered on July 4th still profiling under the pressure ridge with the aid of divers Tom Grenfell and Don Perovich and a helicopter rescue effort directed by Jay Ardai and Al Hielscher plus expert flying by Giles Porter of Luft

Transport. The same instrument was redeployed on floe C2 which drifted west across Fram Straits making hourly profiles. These data should provide a unique record of the oceanic structure in the upper 200 meters in the Fram Straits. The same helo team made a difficult recovery at the end of the experiment at a range of about 75 miles in patchy fog. In addition to temperature and current instrument #70 recorded light transmission data. Figures 1, 2 and 3 show respectively temperature, u-component of velocity and light transmission in the upper 125 meters of the water column. Niskin bottles, water samples and plankton hauls were carried out at 35 and 60 meters at depths determined by local maxiumum and minimum light transmission to see if these were caused by specific organisms which might be used as water tracers for the flows above and below the thermocline respectively.

Technical support for both the mechanical and electronic sections of the Cyclesonde gear were very capably provided by Mr. Larry Burton of the University of Miami Ocean Technology Group at RSMAS. Computer support was provided ashore by Mr. Peter Vertes (RSMAS programmer) and at sea by Mr. Jay Villanueva a graduate student at RSMAS. Mr. Villanueva plans to do a Ph.D. dissertation based upon the cyclesonde and other data collected during MIZEX '84.

TABLE OF CYCLESONDE DATA COLLECTED IN MIZEX '84

Tape #	Instr #	Launched Day/Hrs	Recovered Day/Hr	Profiles Recorded	Site	Sample Rate (Sec)	Profile Interval (Hrs)
1	71	165/19Z	167/14Z	12	A	30s	1h
2	66	166/17	168/15	23	C3	30s	1h
3	64	167/11	171/17	4	C3	30s	1h
4	66	169/10*	174/10*	0	C1	30s	1h
5	71	170/12	170/21	0	B1	30s	1h
6	64	173/10*	175/10*	0	B1	30s	1h
7	71	174/11	178/5	91	C1	30s	1h
8	70	177/14	178/16	3	B2	10s	1h
9	64	178/9	181/7	4	C1	30s	2h
10	19	175/10	184/6	172	B1	30s	1h
11	71	181/12	186/14	96	C1	30s	1h
12	70	182/14	187/15	82	B2	30s	1h
13	64	187/13	196/12	52	B1	30s	1h
14	19	188/9	198/13	240	C3	30s	1h
15	71	189/14	202/11	183	C2	30s	1h
16	70	192/10	193/13	39	B2	10s	0.5h
17	70	196/11	198/10	60	B2	10s	0.5h
18	64	197/09	199/20	29	B1	5s	0.5h
19	70	198/13	199/19	60	B2	10s	0.5h
				1,150			

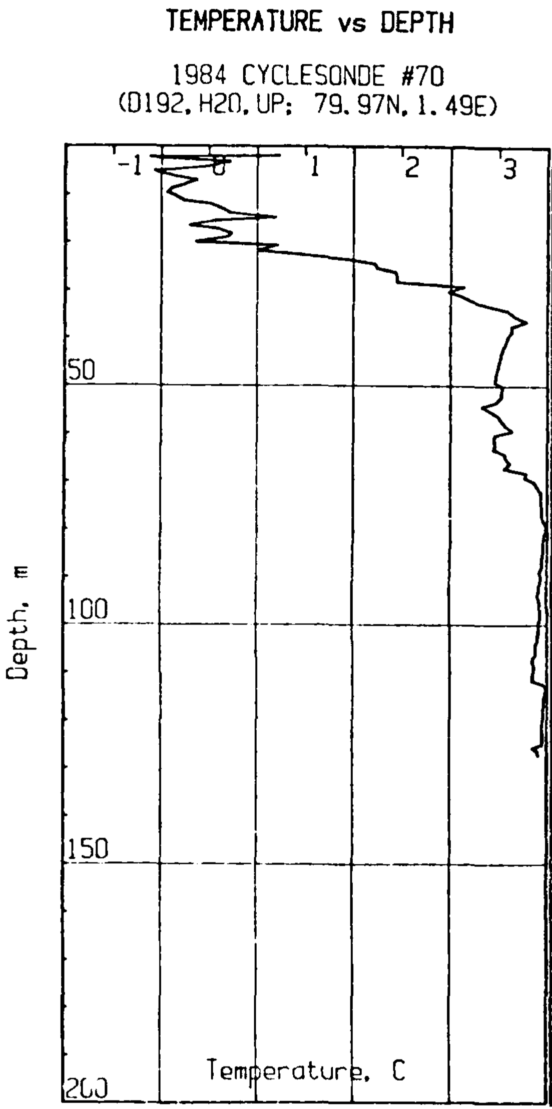
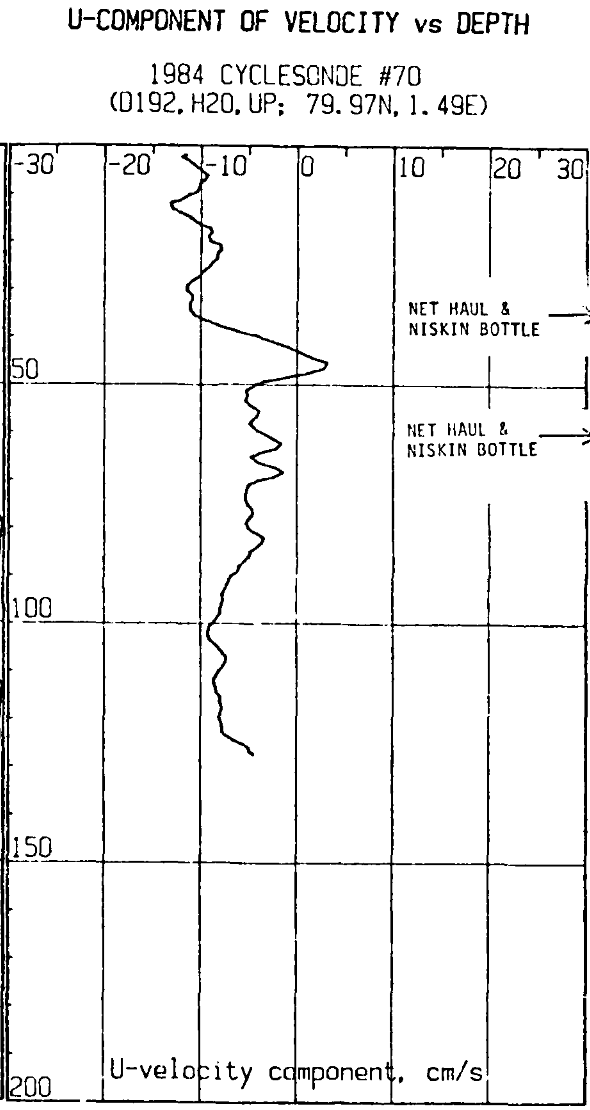


Figure 1.



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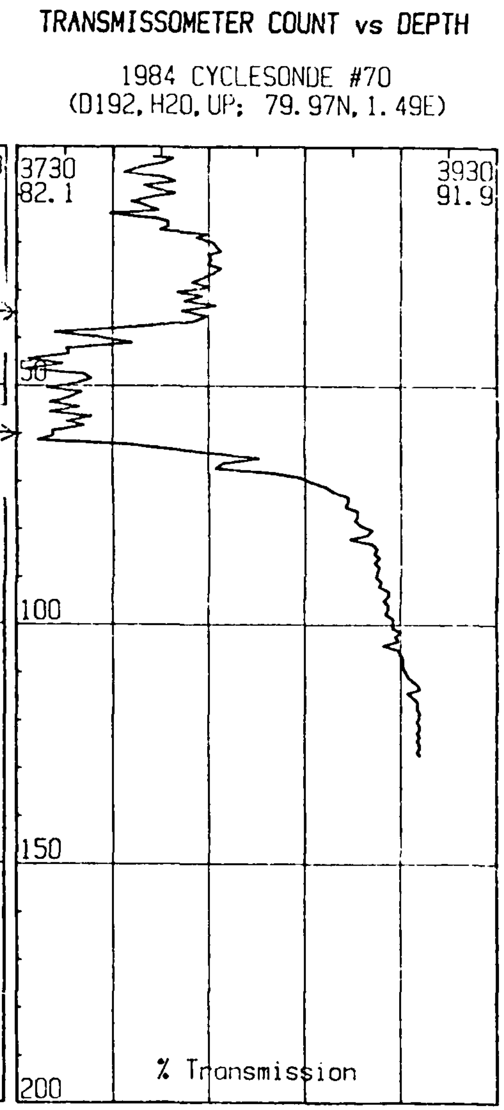


Figure 3.

ARCTIC PROFILING SYSTEM OBSERVATIONS

Dr. James Morison

During MIZEX 84 we conducted an intensive study of the upper ocean at the *Polar Queen* drifting stations. A profiling current meter-CTD system called the Arctic Profiling System (APS) was used to measure profiles of temperature, conductivity and horizontal velocity to depths down to 270 m. Standard casts were made every three hours in order to monitor continuously changes in the mixed layer and upper ocean. Approximately ten sequences of continuous profiles were performed. These ranged in length from 12 to 24 hours. They were conducted during each storm to ensure high resolution coverage of storm-induced transients and at other times to examine the background internal wave field and other high frequency motions. A total of 1,082 APS casts were made in the course of MIZEX 84.

At the first drifting site we were able to make measurements during two storms, including one during which the ice was swept out over warm water. The data from this period, combined with the turbulence measurements by Miles McPhee, should prove to be an excellent study of boundary layer and mixed layer dynamics under stable conditions. Strong near-inertial period motions were also observed at this site. Experiments at the first site ended when the floe drifted out to the ice edge and broke up.

The second drift site was at a very large flow farther into the pack. Surface water temperatures were generally colder and we were able to study the upper ocean response to ice motion for conditions which were not so highly stratified. The longest continuous records were obtained at the second site.

POLAR QUEEN Turbulence Frame Experiment

Miles G. McPhee

The turbulence frame experiment for MIZEX 84 was designed to measure mean flow, temperature, conductivity, and turbulent fluctuations in the flow, at several levels in the upper ocean boundary layer beneath drifting ice. Special instrument clusters were built consisting of three small (4-cm diameter), partially ducted rotors mounted along three mutually orthogonal axes, plus Sea Bird conductivity meters and oceanographic thermometers. Data from each cluster were tranmitted to the surface, converted to digital frequencies by a custom interface deck unit, and recorded on floppy disk with a Hewlett-Packard microcomputer. The system is capable of handling 7 clusters (35 data channels) at a sampling rate of 6 per second.

Clusters were mounted at various levels on a frame of stainless rods bolted together and suspended through a hole in the sea ice located some distance from the **POLAR QUEEN.** The computer and interface were housed near the main hydrohole in a heated tent shared with the University of Washington Mobile Arctic Profiling System (MAPS) project. Clusters were assembled in a standardized jig, and aligned carefully at deployment time with carpenter levels. Each frame was weighted with ballast to ensure that it remained near vertical.

For accurate current measurement, the system depends on current shear between the sea ice and the upper ocean, since the current meters have threshold velocities of about 1 cm/s headon to the instrument. Fortunately, MIZEX 84 saw a number of fairly energetic drift events which developed well defined boundary layers near the ice/ocean interface. A real-time display of the horizontal current vector at each level was used to 'tune' the masts to an optimum orientation so that all current meters in the cluster were turning at roughly equal rates. Coriolis turning in the boundary layer prompted use of two frames close together: one with shallow clusters (typically 1, 2, 4 m below the ice); the other with deep clusters (7, 15 m) usually oriented about 20-30 degrees clockwise from the shallower. On several occasions, the temperature, conductivity, and horizontal currents were compared with data from the MAPS, which uses similar sensors in a vertical profiling mode. These comparisons were usually quite close.

As described elsewhere in this report, the POLAR QUEEN underwent two separate drifts. Setup and initial tests occupied most of the first drift; measurements were recorded from day 164 (12 Jun) to breakup on day 168. The main turbulence frames (suspended through the same hydrohole with instruments at 1, 2, 4, 7, 15 m below the ice) were

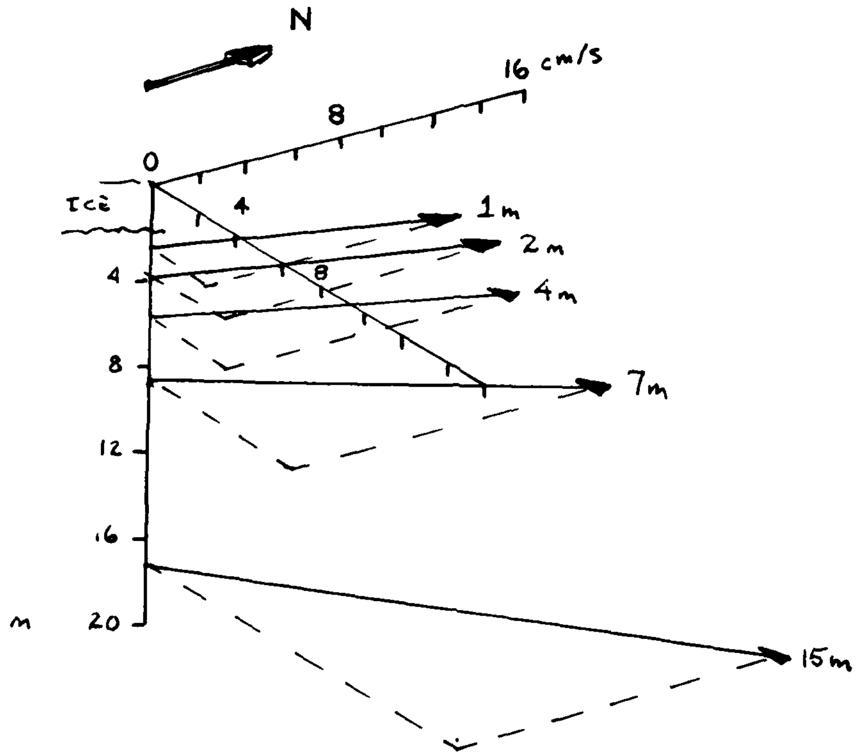
re-established and recording at the second floe by day 174 (22 Jun). A third frame with one cluster at 2 m below the ice, located about 100 m from the main site, was added on day 176. This basic configuration was maintained until the end of the second drift. A total of 205 hours of turbulence data sampled 6 times per second were recorded during the project.

During the latter part of the second drift, the system was also used to test a prototype Diode Laser-Doppler Velocimeter developed by Flow Industries, Inc. This instrument sampled two components of flow by measuring Doppler shift of coherent light scattered from microscopic particles in a small (order 1 cm dimension) volume. A special operating mode in the interface deck unit allowed sampling of the DLDV at 48 Hz, so that the high wave-number region of the turbulent spectrum could be investigated. The DLDV was mounted near one of the standard turbulence clusters at 2 m on a separate frame for comparison of lower wave-number response. A total of about 5 hours of intercomparison runs were made.

Averaging and analysis routines were developed in the field for data verification. Attached is a representative average which shows perspective views of currents (averaged for about 5 minutes) at 5 levels in the boundary layer. In the upper figure, the horizontal components are shown as they were measured, i.e., relative to the drifting ice. Construction lines for the horizontal vectors show the 'x' (eastward) component increasing with depth. Clockwise rotation with increasing depth was present nearly all the time in the measurements; exceptions being when the mixed layer deepened past the instrument cluster at 17 m (15 m below the ice). This happened only once or twice; usually the salinity and density increased rapidly below 10-12 m, so that there was a strong pycnocline within the vertical domain of the cluster frame.

The lower view shows currents in a fixed-to-earth reference frame, obtained by adding the ice-drift velocity to the relative measurements. The remanent current at 15 m is probably not due to surface stress, but is part of a time-varying baroclinic structure often present in the stratified fluid below the mixed layer.

Overall, the turbulence frame experiment appeared reasonably successful. The data collection system and most of the sensors performed well. In both drifts, large variations in upper ocean temperature and stratification conditions were encountered, which should provide insight into MIZ mixed layer dynamics not available before.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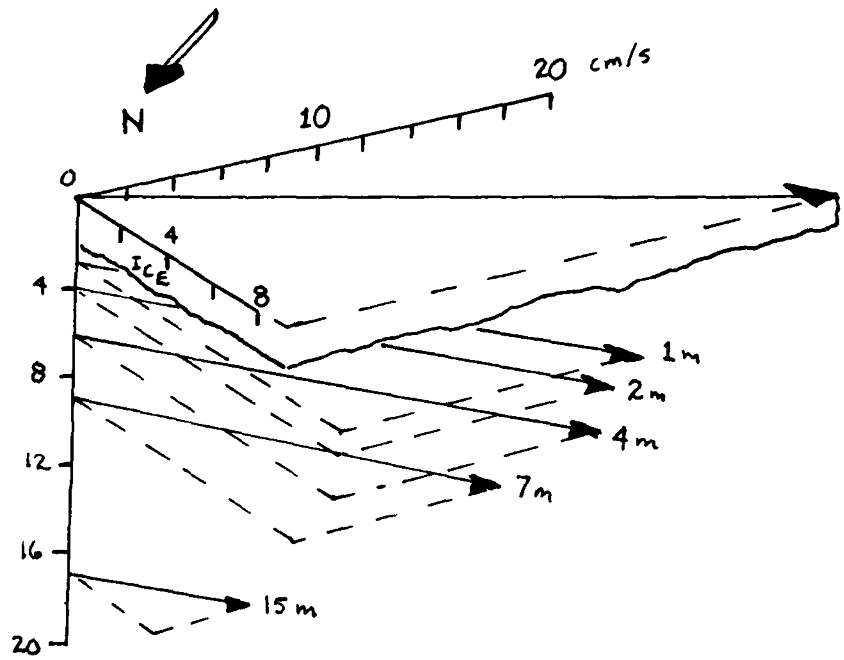
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TRITIUM LABORATORY FIELD OPERATIONS

Z. Top and H. Gote Ostlund

During the MIZEX 84 field work, our objectives were mainly to collect samples for the analyses of dissolved noble gases, oxygen isotopes, and tritium. In addition, we made dissolved oxygen measurements in the water column, on board M/V POLARQUEEN.

A total of 72 noble gas samples and 72 tritium samples were collected. These include detailed sampling for noble gases in the mixed layer (12 samples in the upper 20 meters), surface tritium samples every other day, ice core samples, and snow samples. Each noble gas sample yields three aliquots; one for helium 3/helium 4 isotopic ratio, one for the concentrations of total helium and neon, and one for the concentrations of argon, krypton and xenon. Samples for oxygen isotope analyses are drawn from the tritium samples. The objectives of our field operations were achieved with excellent cooperation of colleagues and the crew of the M/V POLARQUEEN. Results of the dissolved oxygen measurements were obtained on board, however these were further processed and are presented in Figure 1.

The purposes for the above mentioned measurements are as follows: 1) To determine the dissolved neon/helium ratios under summer conditions. Previous measurements of neon and helium showed that there exists anomalous concentrations of neon in the Arctic regions, and the anomaly may be explained by repetitive freezing-melting events (Top et al., 1983). Further it was postulated that argon, krypton and xenon must be in excess of their respective saturation values. Oxygen is also expected to be supersaturated due to the freezing-melting cycle, however its production by phytoplankton and its consumption by zooplankton makes the budgeting calculations somewhat difficult. With the present results we expect to confirm the anomalies and to obtain correlations between them. 2) To obtain as detailed tritium distribution as possible across the Fram Strait. The temporal variation of tritium in the high latitudes gives information a) on the vertical mixing processes, b) in conjunction with the oxygen isotopes on the abundance and life time of the freshwater component (Ostlund and Hut, 1984) and c) in conjunction with helium-3, on the isolation time of a water parcel (time elapsed since last contact with the atmosphere).

The collected samples are expected to arrive in Miami in mid-September, at which time they will be processed and analyzed. Final results should be available within approximately nine months thenceforth.

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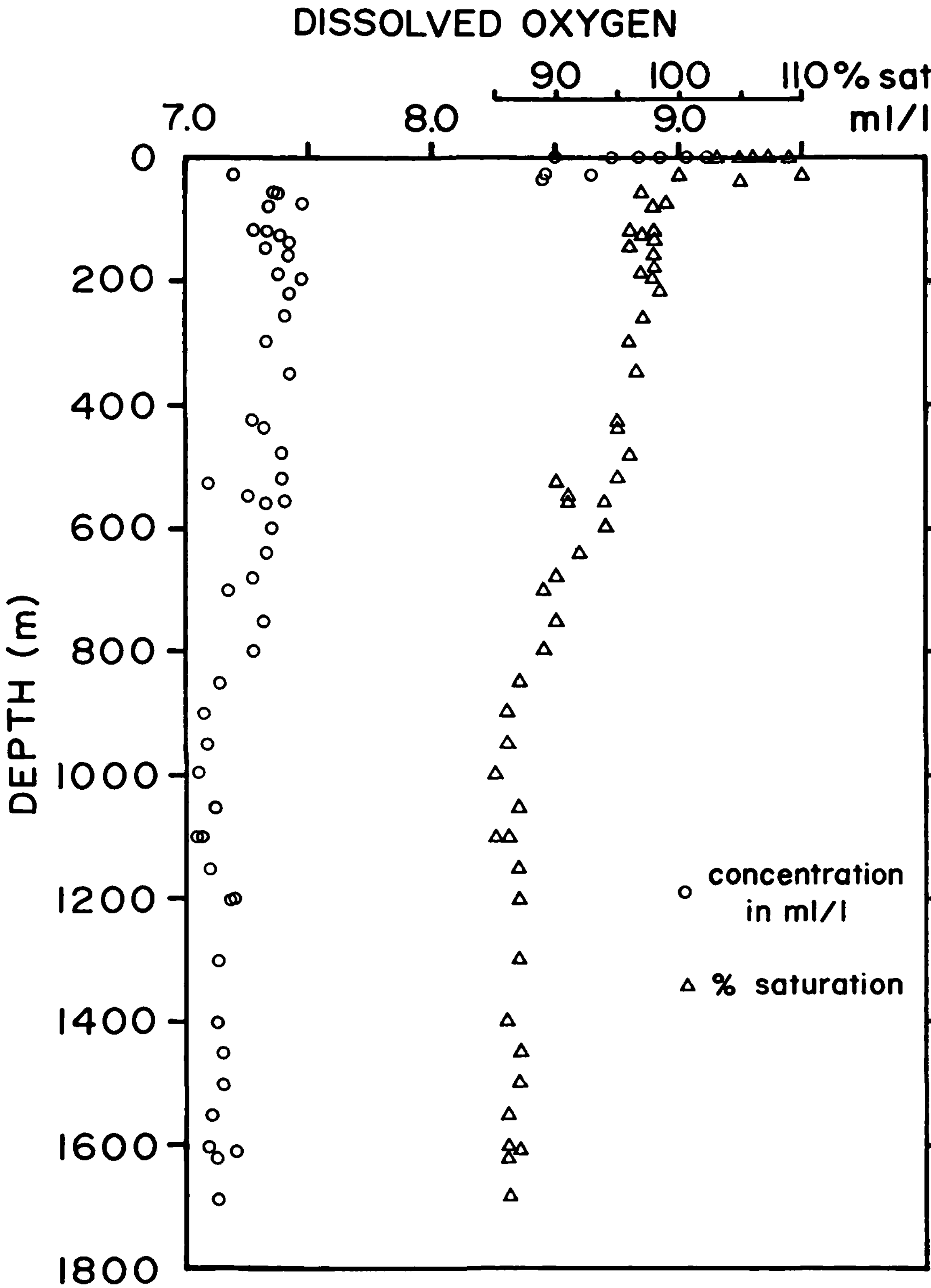


FIGURE 1. Dissolved oxygen profile in the Fram Strait during MIZEX 84 program.

MIZEX-84 OCEANOGRAPHY CRUISE REPORT, KVITBJØRN (POLARQUEEN)

Einar Svendsen
Bergen MIZEX Group*, Geophysical Institute, University of Bergen, Norway

40 Aanderaa current meters distributed on 10 rigs, 3 automatic weather stations and 3 thermistor chains were deployed (from Kvitbjørn and Polarqueen) anchored to ice floes. Some of these were tracked by radar transponders in connection with the accoustic program (I. Dyer) and the minidrift program (P. Wadhams), the rest were tracked by Argos buoys. A total of 9 Bergen Argos buoys were deployed. Due to persisting northerly winds with equipment drifting out in open water and out of radar transponder range, most of the sites were redeployed at least twice. The current meter and thermistor data has not yet been processed.

In addition to the above mentioned activities, 327 CTD stations were taken from Kvitbjørn together with standard meteorological observations every 10 minutes (wind velocity at 10 m height, air/sea temperature). Fig. 1 shows the track of Kvitbjørn and the CTD sections taken. During the Kvitbjørn accoustic drift phase (June) and the two minidrift phases, CTD stations were in general taken every hour to 500 meters depth. However, this time serie was broken up due to frequent redeployment work. In addition some shorter periods of 3 minutes and 10 minutes CTD sampling to 100 meter depth were performed to look for internal high frequency waves. However, the main features seen were variations of isotherms and isohalines of 10-20 meters over 2-4 hour time pericds. Together with the thermistor and current measurements every 2 minutes, and the acoustic program (I. Dyer), this will be an interesting dataset for the internal wave studies and its influence on acoustics.

During the second phase (July) of Kvitbjørn (except for the minidrifts) the main CTD program comprised sections through eddies, some of these together with R/V Håkon Mosby. With the aid of satellite and aircraft remote sensing, we were directed to areas where the ice edge configuration showed indications of eddies. A section plot of isotherms through such an eddy is shown in Fig. 2. This shows that a patch of cold Arctic surface water is moved far out from the ice edge, separated by warm Atlantic water in the senter which is lifted to the surface.

Several of the current meter rigs (some equipped with ice ablation gear, E. Josberger) were for shorter periods at the very ice edge, and one rig drifted into one of the eddies studied by CTD. Due to the frequent redeployment, most of the current meter data are of shorter time series, however, they might prove to be very interesting datasets of features very close to the ice edge.

Small scale ice cube melting experiments were successfully carried out during instrument calibration periods.

*Bergen MIZEX Group: O.M. Johannessen, J.A. Johannessen, E. Svendsen, B. Farrelly, S. Sandven, T. Olaussen, S. Myking and A. Revheim.

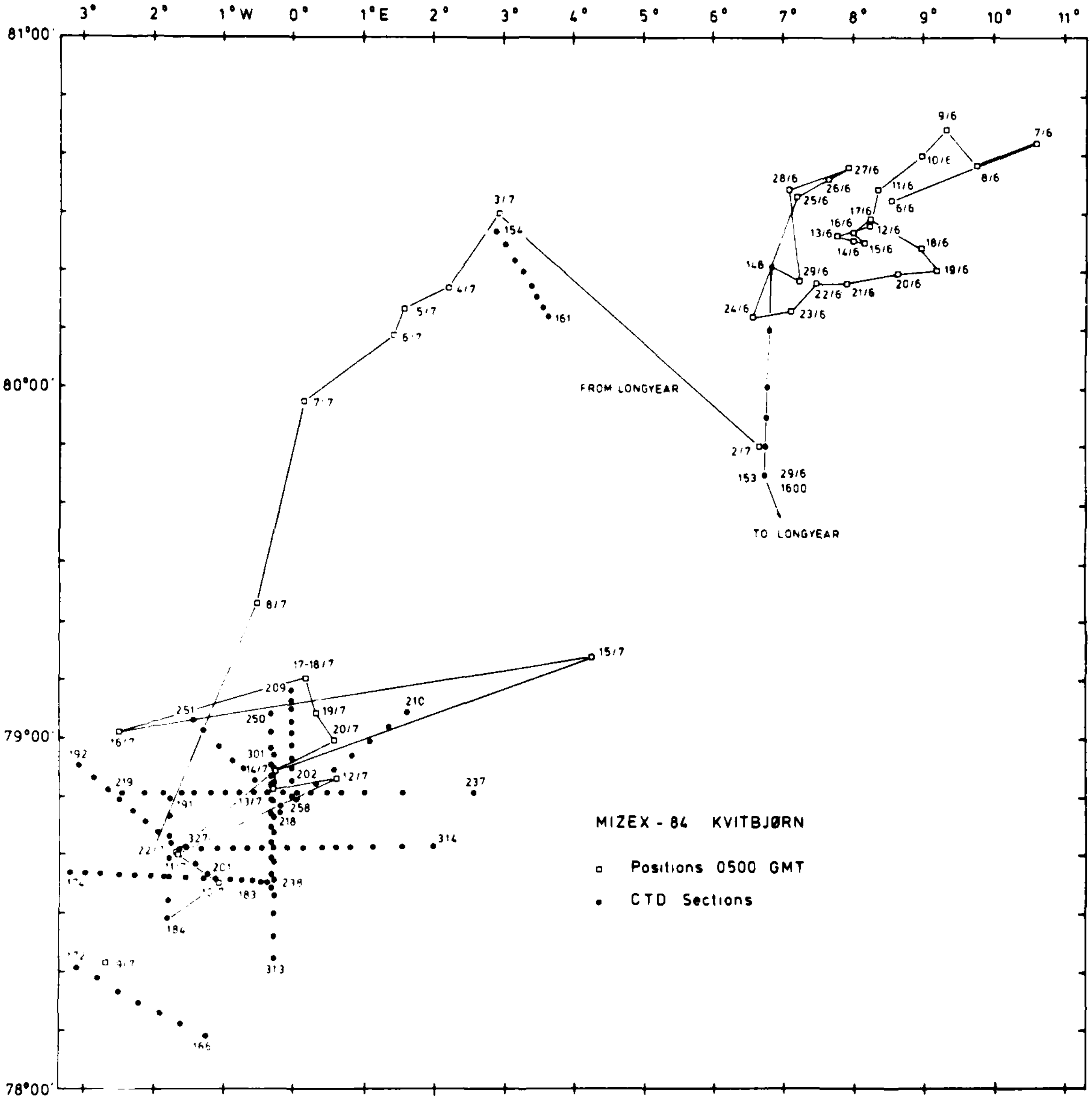
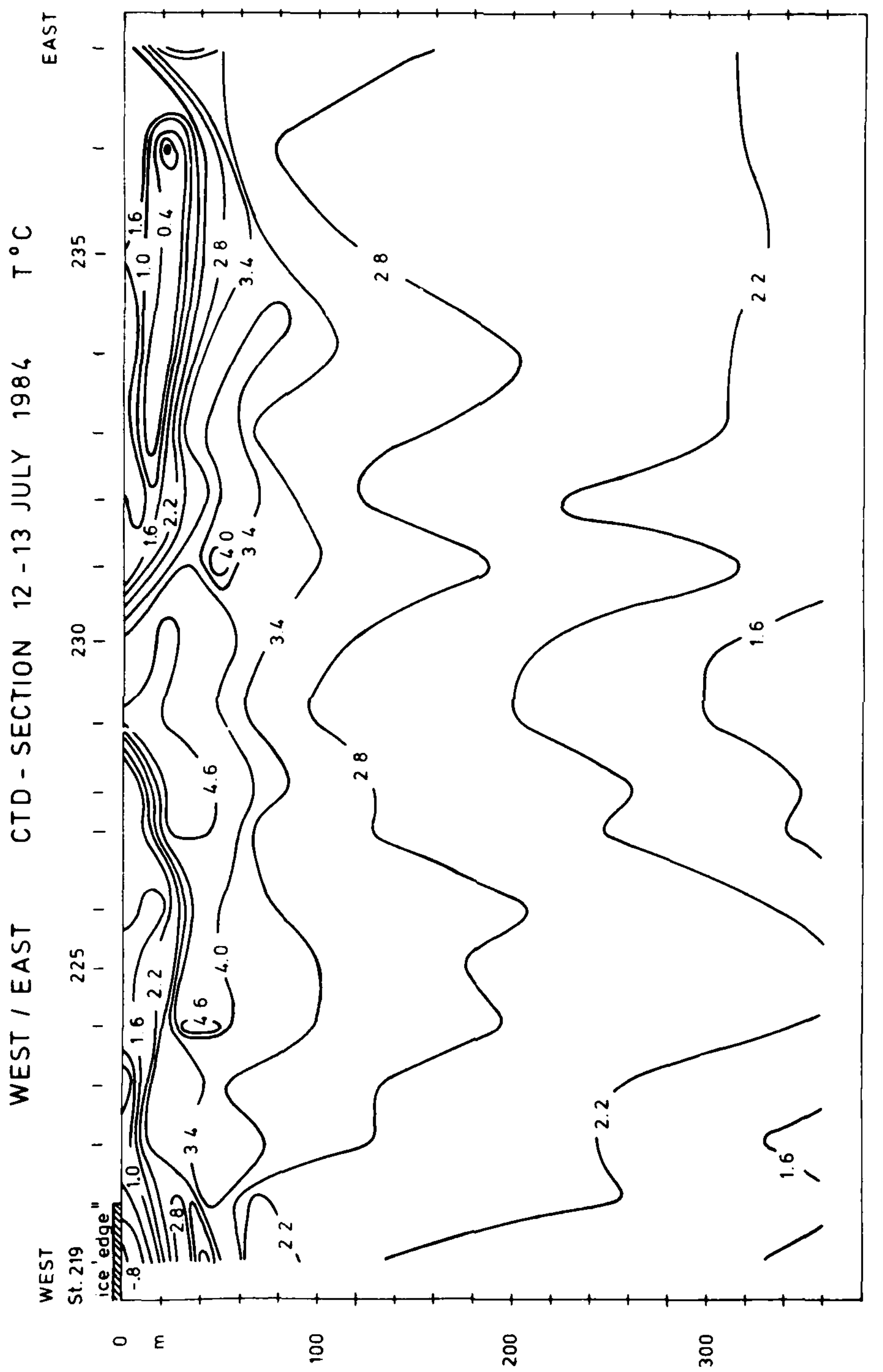

MIZEX - 84 KVITBJØRN
Positions 0500 GMT
CTD Sections
FROM LONGYEAR
TO LONGYEAR
81°00'
80°00'
79°00'
78°00'
3°
2°
1°W
0°
1°E
2°
3°
4°
5°
6°
7°
8°
9°
10°
11°

Fig. 1



WEST / EAST CTD - SECTION 12 - 13 JULY 1984 T °C
WEST
EAST
St. 219
"ice edge"
225
230
235
0 m
100
200
300
-.8
1.0
1.6
2.2
2.8
3.4
4.0
4.6
0.4

Fig. 2

MIZEX OCEANOGRAPHY CRUISE REPORT FROM R/V HÅKON MOSBY

Johnny A.Johannessen
Bergen MIZEX Group*, Geophysical Institute, University of Bergen, Norway

This report includes the oceanography program carried out by the Univ. of Bergen group from the open water ship R/V Håkon Mosby during MIZEX 1984. The other main programs in meteorology, acoustic tracking of sofar/VCM floats and whitecaps studies carried out from R/V Håkon Mosby are reported by their respective PI's.

451 CTD stations were obtained in 53 CTD sections, 94 XBT's were dropped in 9 sections, surface temperature was continuously recorded with a towed thermistor and water samples were taken for deriving salinities. In addition Argos surface drifting buoys were recovered and redeployed from R/V Håkon Mosby. The synoptic and mesoscale CTD programs including station numbers, section numbers, station spacing and sampling depths are listed in the table below. The table also contains a listing of the XBT program. A map of the corresponding CTD section tracks are shown in Figure 1a and 1b.

Preliminary analysis of this data set suggests that at least 3 different eddy features were mapped. One eddy was detected during the first synoptic CTD program with a center at approximately 79°50' N and 6°30'E. The diameter of this eddy was about 20-25 km. (Fig. 2). It was first tracked for 4 days with CTD sections taken in a star pattern through the eddy center and revealed almost no propagation. At the same time the ice edge, initially located just north of the eddy center, moved northward about 60 km. The second tracking period 7 days later gave no sign of the eddy. This may imply a decay time in the order of 10 days.

Second, the existence of the "stationary" Molloy Deep eddy with a scale of 60-100 km was revealed by 3 sections all sampled to the bottom.

Third, eddy tracking with scales of 20-50 km along the ice edge south of 79°N was carried out in coordination with R/V Kvitbjørn. Location of eddies by aircraft and satellite remote sensing in near real time enable guidance of the ship towards the eddy feature.

In addition to the mesoscale eddy tracking program, the strong frontal zone between waters of Atlantic and Arctic origin in the Fram Strait was mapped from R/V Håkon Mosby during the synoptic scale program by CTD stations and towed surface thermistor.

Both the mesoscale and synoptic scale oceanography prgram carried out from R/V Håkon Mosby will contribute to the study and understanding of the large scale oceanography between Svalbard and Greenland.

Small scale ice cube melting experiments were successfully carried out during instrument intercalibration periods.

* Bergen MIZEX Group: O.M.Johannessen, J.A.Johannessen, E.Svendsen, B.A.Farrelly, S.Sandven. T.Olaussen, S.Myking and. A.Revheim.

TABLE [illegible]

CTD PROGRAM OVERVIEW
HÅKON MOSBY 12 JUNE - 18 JULY

SYNOPTIC CTD PROGRAM 18-22 JUNE.

SECTION NUMBERS	STATION NUMBERS	ST.SPACING	SAMPL.DEPTH
1	5-15	2.5,5,10 nm	500/1500
2	16-21	"	500/1500
3	22-30	"	500/1500
4	31-39	"	500/1500
5	40-45	"	500/1500
6	47-54	"	500/1500
7	55-59	"	500/1500
8(3)	60-68	"	500/1500
9(4)	69-74	"	500/1500
10(5)	75-84	"	500/1500
11(6)	85-91	"	500/1500
12(7)	92-98	"	500/1500
13(A)	99-108	5, 10 nm	500/1500

MESOSCALE CTD PROGRAM 22-26 JUNE and 3-4 JULY

SECTION NUMBERS	STATION NUMBERS	ST.SPACING	SAMPL.DEPTH
14	109-127	2.5, 5nm	500
[illegible]	128-139	"	500
[illegible]	140-155	"	500
[illegible]	156-166	"	500
[illegible]	167-171	"	500
[illegible]	172-178	"	500
[illegible]	179-187	"	500
[illegible]	188-196	"	500
[illegible]	197-203	"	500
[illegible]	204-216	"	500

[illegible]

SECTION NUMBERS	STATION NUMBERS	ST.SPACING	SAMPL.DEPTH
33	283-296	2 nm	500
34	297-306	"	500

CTD BOX AROUND THE MESOSCALE FEATURE 26-30 JUNE.

SECTION NUMBERS	STATION NUMBERS	ST.SPACING	SAMPL.DEPTH
24	217-225	10 nm	1500
25	225-230	"	1500
26	230-236	"	1500
27	236-242	"	500
28	243-255	5 nm	500/1000
29	256-263	2 nm	500

[illegible]

SECTION NUMBERS	STATION NUMBERS	ST.SPACING	SAMPL.DEPTH
30	[illegible]	[illegible]	[illegible]
31	[illegible]	"	"
32	[illegible]	"	"

MESOSCALE SYNOPTIC CTD PROGRAM 5-9 JULY.

SECTION NUMBERS	STATION NUMBERS	ST.SPACING	SAMPL.DEPTH
35	307-314	2.5 nm	
36	315-324	"	
37	325-332	"	
38	332-341	"	
39	342-355	2.5, 5 nm	[illegible]
40	355-361	5 nm	
41	358, 361-368	"	[illegible]

MESOSCALE CTD PROGRAM 9-14 JULY

SECTION NUMBERS	STATION NUMBERS	ST.SPACING	SAMPL.DEPTH
42	370-374	2 nm	500 m
43	375-378	randomly spaced ctd. casts	
44	379-384	2 nm	500
45	386-390	2.5 nm	500
46	391-396	"	500
47	396-401	"	500
48	402-410	"	500
49	411-420	"	500
50	421-427	"	500
51	428-435	"	500
52	436-446	3 nm	500
53	447-451	2.5 nm	500

XBT PROGRAM OVERVIEW
HÅKON MOSBY 12 JUNE-18 JULY

SECTION NUMBERS	STATION NUMBERS	POSITION START	POSITION END	SAMPL. DEPTH
1	2-16	Front tracking between		
		79°40'N and 79°09' N		700 m
2	17-22	79°28'N	79°15' N	
		1°27' E	2°59' N	700
3	23-35	79°10'N	78°40' N	700
		3°05' E	1°40' N	700
4	36-45	79°01'N	79°07' N	
		0°26'E	3°47' E	700
5	46-53	79°10'N	78°28' N	
		3°44'E	1°55' E	700
6	55-61	78°22'N	78°25' N	700m
		0°22'W	2°25' W	700
7	62-65	78°41'N	78°45' N	
		1°43'W	1°47' W	700
8	67-76	79°15'N	78°29' N	
		3°52'E	0°33' W	700
9	77-94	78°21' N	76°06' N	700
		[illegible]°11' E	5°16' E	

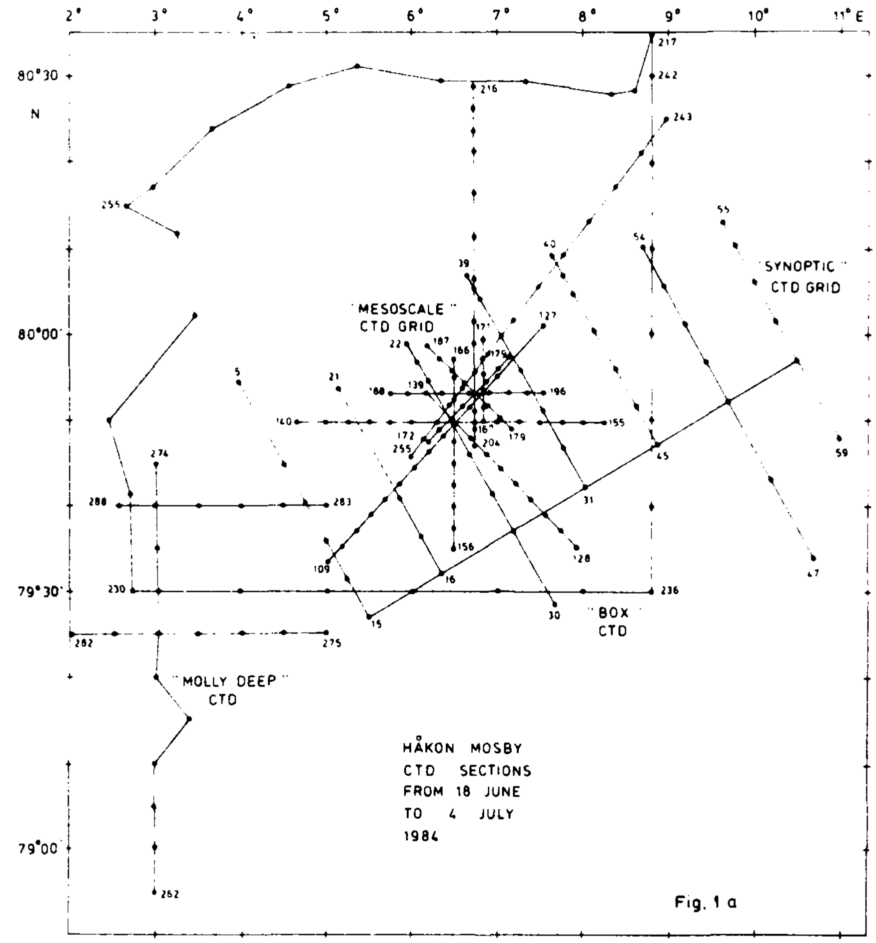

"MESOSCALE" CTD GRID
"SYNOPTIC" CTD GRID
"BOX" CTD
"MOLLY DEEP" CTD
HÅKON MOSBY
CTD SECTIONS
FROM 18 JUNE
TO 4 JULY
1984

Fig. 1 a

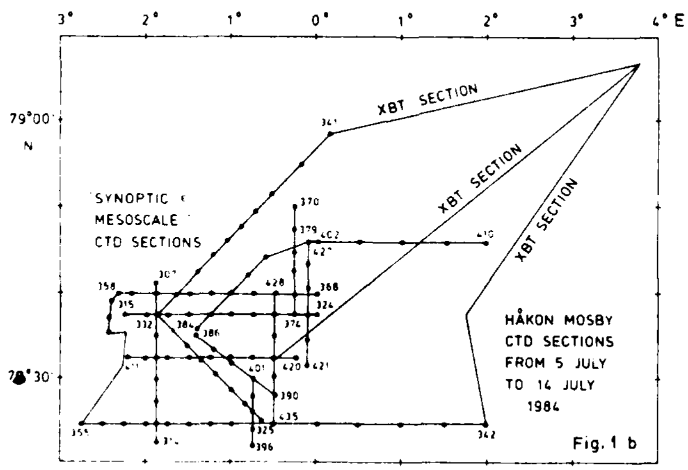

XBT SECTION
XBT SECTION
XBT SECTION
"SYNOPTIC" & "MESOSCALE" CTD SECTIONS
HÅKON MOSBY
CTD SECTIONS
FROM 5 JULY
TO 14 JULY
1984

Fig. 1 b

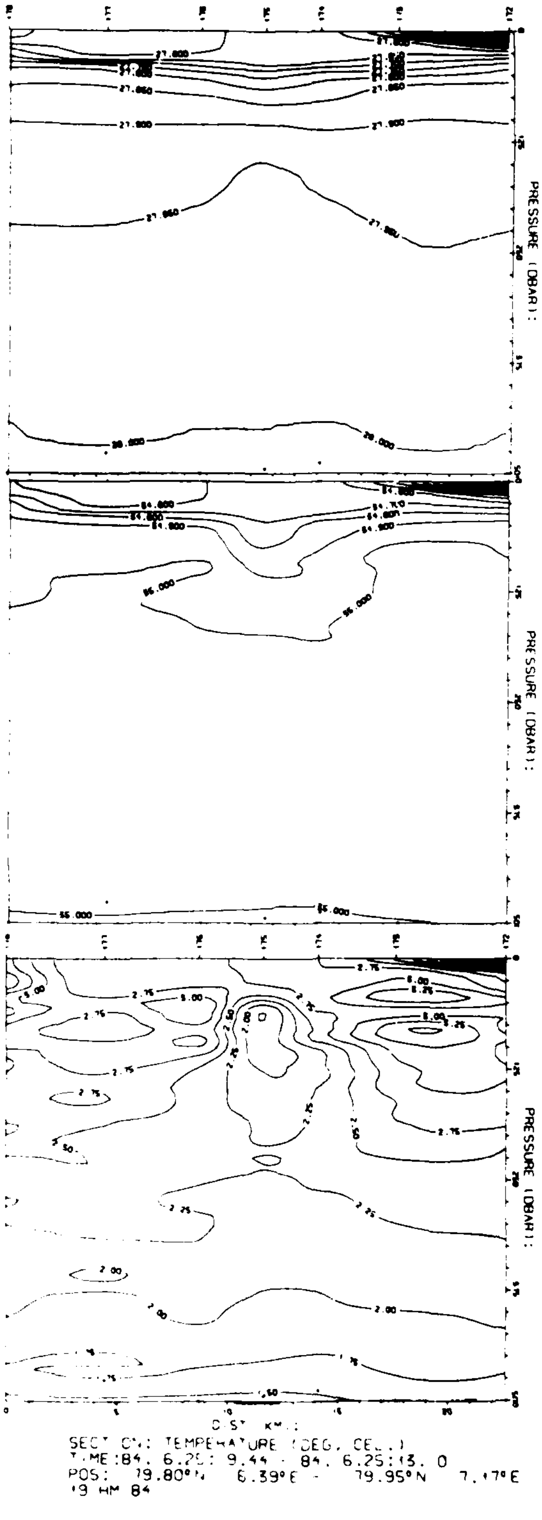

PRESSURE (DBAR):
PRESSURE (DBAR):
PRESSURE (DBAR):
TEMPERATURE (DEG. CEL.)
TIME:84. 6.25: 9.44 - 84. 6.25:13. 0
POS: 79.80°N 6.39°E - 79.95°N

Fig. 2

Hydrographic and current observations in the eastern Fram Straits, RV VALDIVIA

Detlef Quadfasel, Horst Baudner, Peter Damm and Klaus Schulze

Hydrographic observations have been made from aboard RV VALDIVIA in the eastern part of Fram Straits during 22 June to 18 July 1984 employing a CTD (ME-Multisonde) supplemented by a 20 bottle rosette sampler. Station positions are shown in Fig. 1. Current measurements were made in the West Spitzbergen Current by use of four satellite tracked drifting buoys.

1. Large scale program: Three sections at 80°20'N (12 Stns), at 78°55'N (15 Stns) and at 77°30'N (24 Stns) were occupied between the ice edge and the coast of Svalbard. Additional 22 stations were run during the meteorological program in the area of 78°N, 7°E (Fig. 1, heavy dots). All profiles extend from the surface to 5 m above the bottom. XBT sections were run on transit between CTD sections, station spacing varied between 3 and 10 nautical miles. (thin lines in Fig.1).

2. Synoptic scale program: Four sections consisting of ten CTD-stations each were occupied at 77°40'N, 77°55'N, 78°10'N and 78°55'N (Fig. 1, crosses), spanning an area from the ice edge to about 35 miles into the open water. Sampling depths were 500 m and 1500 m alternatively.

3. Mesoscale program: Centered at 80°10'N, 3°E five sections were occupied with a profile depth of 500 m (Fig. 1, light dots). On their own probably not sufficient in coverage, these sections were intended to support the intensive mesoscale surveys of Hakon Mosby and Kvitbjorn.

4. Drifting buoys: Surface current measurements were obtained from drifting buoys equipped with ARGOS transmitters. Three were deployed on 78°N at 20 miles spacing, one at 78°30'N north of this row. The expected life-time of the buoys is about 6 months.

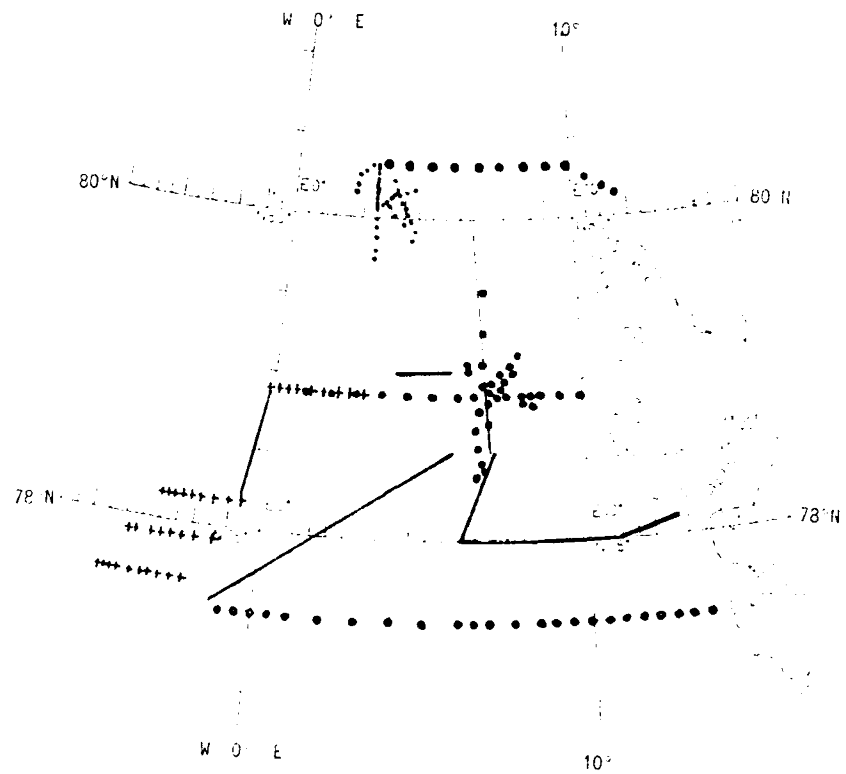


Fig. 1: Hydrographic station positions, VALDIVIA 21, MIZEX 84

● CTD 0-bottom (large scale)

+ CTD 0-500/1500 m (synoptic scale)

· CTD 0-500 m (mesoscale)

— XBT sections

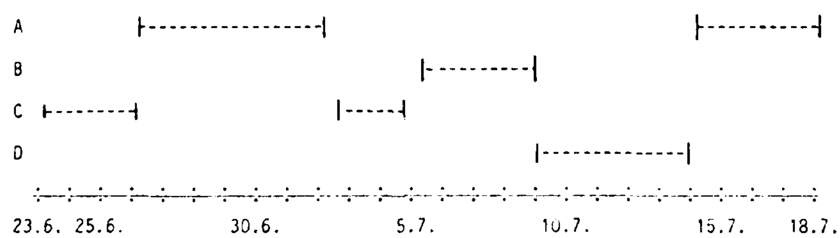


Fig. 2: VALDIVIA observational program

A: large scale

B: synoptic scale

C: mesoscale

D: meteorological

Surface currents measured by means of CODAR

H.-H. Essen

CODAR (Coustal Oceanic Dynamics Application Radar) measures the radial component of surface currents up to a distance of 50 km with a resolution of 1.2 km. Two measurements at different positions are necessary in order to obtain the 2-dimensional current vector. During MIZEX, these measurements were performed successively, assuming the currents to be stationary for times of 1 to 2 hours.

A new system of receiving antennas on board VALDIVIA was tested twice by means of correction (transmitting antenna on the island Sylt and POLARSTERN, respectively). The angles of arrival could be resolved unambiguously, but there is an inaccuracy of $\pm 15^{\circ}$ in some angular ranges.

Measurements of surface currents were carried out on 3 sections between Svalbard and the ice edge (80° 20'N, 78° 55'N, 77° 30'N). At the ice edge approximately 20 CODAR stations were performed. The positions are shown in Fig.1. Two adjacent stations will yield one 2-dimensional current map. In some cases, also three stations were taken to cover the same area.

One CODAR station takes 18 minutes. During this time the ship's course and speed should not vary. While the course could be kept constant within $\pm 2^{\circ}$, the ship's speed varied up to $\pm 0,5$ knots around 0. For this reason the processing software has to be changed, which will take some time. We hope to finish the data processing within 1 year.

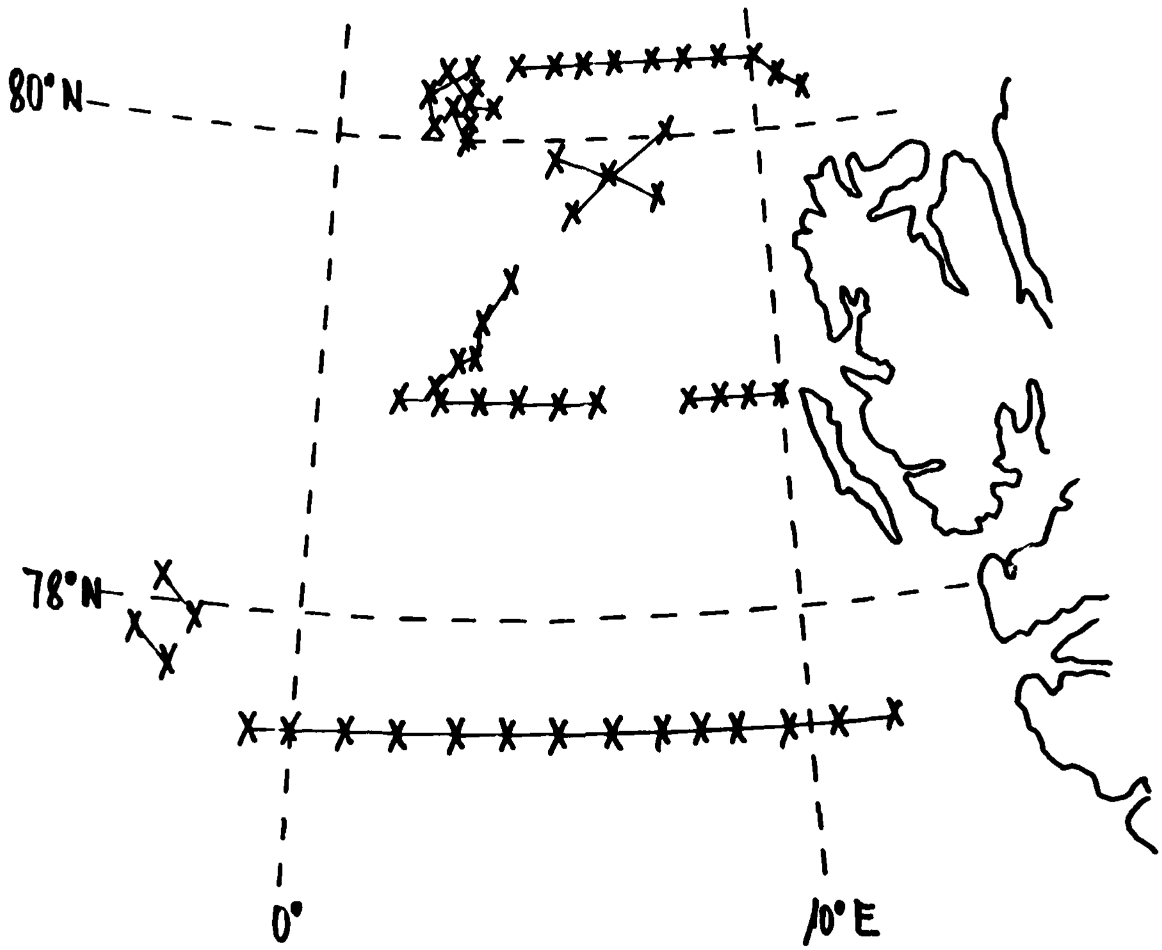


Fig. 1: Positions of CODAR Stations (X) during MIZEX 84

Sea Wave Measurements on Board MS "VALDIVIA" during MIZEX '84

F. Ziemer Institut für Meereskunde, Hamburg, F.R.G.

1. Object in view and planning

The objects in view of part project 01/3a of the MIZEX '84 experiment concerning ms "VALDIVIA" are stipulated in the additional motion of the SFB 94 of October 4, 1983 and can be summarized as follows:

a) Measurements of the particular surface wave and current conditions produced by the ice edge;
b) measurements of waves routinely carried through in order to set up a small scaled data set in a sea region with scanty measurement points;
c) further experience with modified ship radar used for measurement of waves and current.

Regarding a):
The main interest of the projected measurements concerned the specific waves conditions on the borders of the pack-ice. In cooperation with other groups doing measurements in the pack-ice, it was intended to effect measurements in distinguishing cases of two different directions of wind (on-ice-, off-ice winds).

In the presence of on-ice winds the process of the reflection of sea wave and swell from ice edge back to the open sea had to be registered at the same time as the process of attenuation of waves in the pack-ice. For that reason, it was intended to obtain on-board ms "VALDIVIA" sea wave direction spectra respectively the two-dimensional sea wave spectra in short time intervals and in doubling space intervals from the ice edge.

It was also intended to effect measurements in the presence of off-ice winds in rapid time intervals, but in constant spatial distances in order to find out the spatial sea wave stimulation (fetch laws) as well as the influence of the eventually existing ice bands.

The conditions given by the planning of the ship's time schedule permitted such intensive sea wave measurement programs only during the mesoscale measurement phases. The estimated amount of time necessary for such a sea wave measurement operation ranged between 12 and 14 hours, up to 8 stations included in each operation, whereby measurements had to be made in a distance of up to 30 sm from the ice edge.

Regarding b):
Due to the large scaled operations between the ice edge and Svalbord and the 5-days meteorological measurement phase it was possible to effect routinely sea wave measurements in a sea region, where only a few data sets are disposed of. Furthermore, these data can equally be used as reference data for measurements made in the pack-ice as well as for those made by plane.

Due to the long time steps between the stations, however, no stationarity of the sea wave field could be assumed. On the other hand, it was possible to register longer time series of the sea wave development.

Regarding c):
Prior to the voyage the Furuno ship radar had been modified in two points in order to improve his suitability for measurements of sea wave and currents. First the pulse length had been reduced by about 40% (to 38 x 10^{-9} sec) in order to obtain a higher spatial solution, second the rotation amount of the antenna had been reduced to 2 sec which leads to a higher cut-off frequency of

Sea Wave Measurements on Board MS "VALDIVIA" during MIZEX '84

F. Ziemer Institut für Meereskunde, Hamburg, F.R.G.

the three-dimensional sea wave spectra.

2. Instrumentation

In order to realize the intended measurements we disposed of the following measuring instruments:

2 waverider buoys (one dimensional spectra)
2 pitch-and-roll buoys (sea wave direction spectra)
'Furuno ship radar 1200' (normalized two- resp. three-dimensional wave spectra) (Ref. 1, Ref. 2).

The telemetring waverider buoys could be used free floating on 24 stations so that the remaining measuring opeations could be continued without any disturbances. The pitch-and-roll buoys had to be connected by a floating cable with the ship which excluded simultanously effected deep water measurements.

Due to a defect the Furuno ship radar could not be used during the whole measuring phase so that in the course of the first two weeks the radar measurements had to be effected by use of the nautical bridge radar (Atlas 5500).

3. Measurements

A survey of the measurement positions and the used instrumentations is given in Fig. 1. All together, on 7 stations 7 direction spectra could be obtained, on 30 stations 210 one-dimensional spectra and on 21 stations 58 three-dimensional spectra.

As far as the small scaled wave measurements near the ice edge are concerned (item a), one measurement operation for each wind case could be effected. Under on-ice wind conditions (6 m/sec; 110°) a serie of 7 pitch-and-roll buoy stations could be sampled on June 27, 84 (see Fig. 1,a). A serie of waverider and radar measurements (see Fig. 1,b) could be sampled on the early July 8, 84 under off-ice wind conditions (8 m/sec; 320°). Further projected pure sea wave measurement series (concerning item a)) had to be cancelled because of the absence of sea wave and swell.

During the 3 large scaled measurement courses the sea wave measurements could be effected according to the planning - with the exception of 5 stations during the second cut (79° north) due to the fact that the wave rider buoys could not be used because of bad sight conditions.

During the 5-days meteorological permanent station (hatched region in Fig. 1) a nearly complete sea wave time serie could be obtained.

4. References

1) Ziemer, F., Rosenthal, W. and Carlson, H., 1983, Measurements of Directional Wave Spectra by Ship Radar, IAPSO Symposium PS-11, IUGG XVIII, General Assembly, Hamburg.

2) Young, I.R., Rosenthal, W. and Ziemer, F., 1984, A Three-Dimensional Analysis of Marine Radar Images for the Determination of Ocean Wave Directionality and Surface Currents (accepted for publication in J. Geophys. Res.).

Sea Wave Measurements on Board MS "VALDIVIA" during MIZEX '84

F. Ziemer   Institut für Meereskunde, Hamburg, F.R.G.

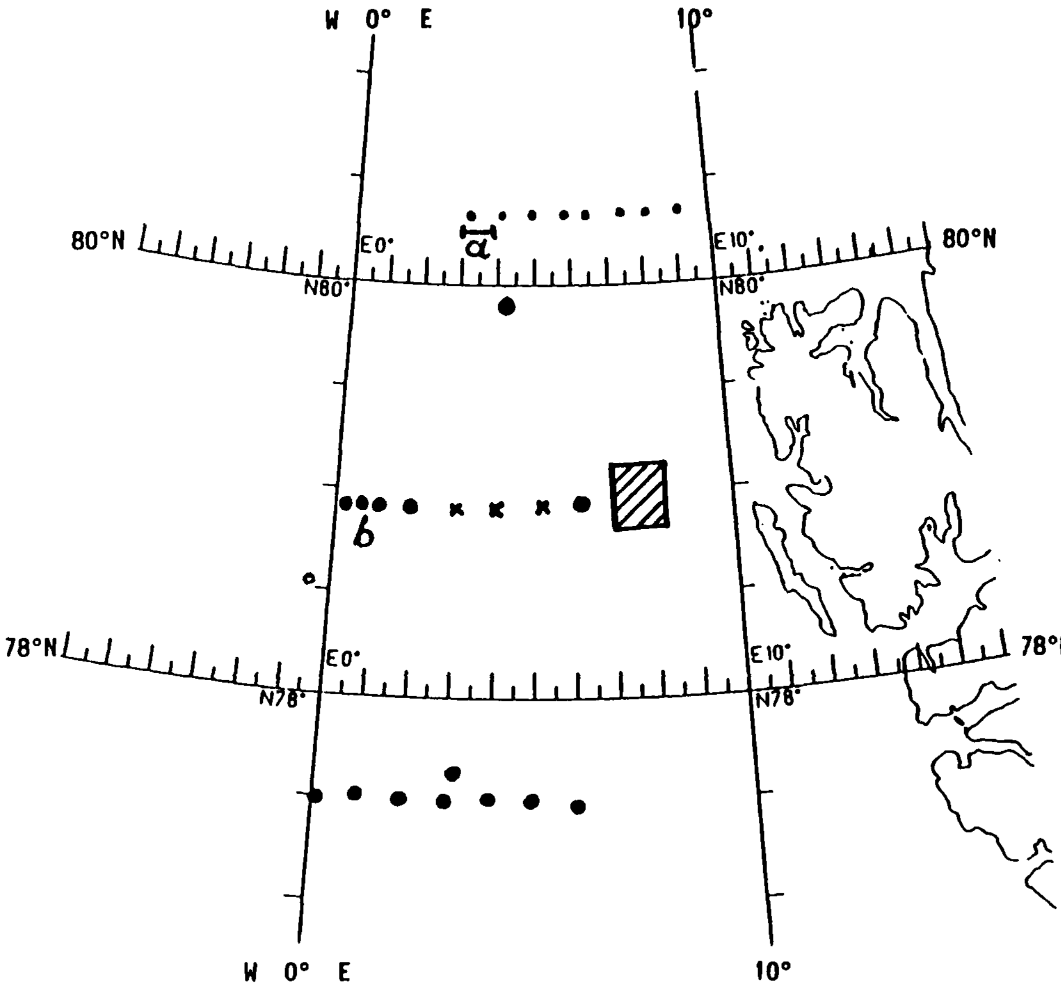


Fig. 1   Positions of Sea Wave Measurements during MIZEX '84, VALDIVIA 21

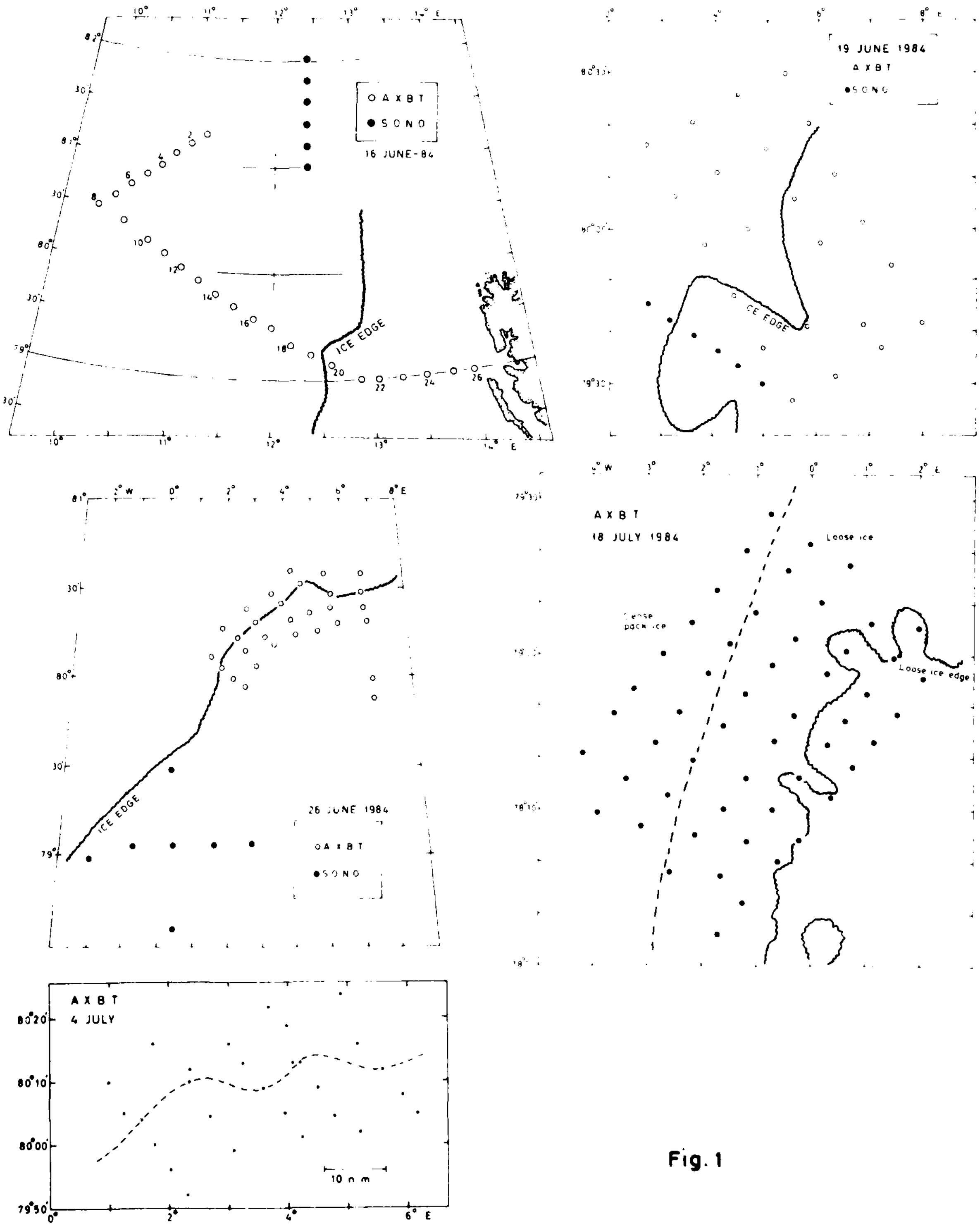
- . waverider buoy
- ● waverider buoy and radar
- x radar
- ⊢⊣ pitch-and-roll buoy (7 stations)
- ▨ waverider buoy and radar during the meteorological program

AXBT AND SONO BUOY DROPS FROM A ROYAL NORWEGIAN AIR FORCE P3

Ola M.Johannessen and B.A.Farrelly, Bergen MIZEX Group *

During MIZEX 84 6 dedicated MIZEX flights were carried out by a Norwegian P3 from the 33 squadron at Andøya. 200 AXBT's and 19 sonobuoys for ambient noise investigation were dropped in the MIZ. Fig. 1 shows the position of the drops and Fig. 2 some preliminary results.

* Bergen MIZEX Group: O.M.Johannessen, J.A.Johannessen, B.A.Farrelly, E.Svendsen, S.Sandven, T.Olaussen. S.Myking and A.Revheim



OAXBT
●SONO
16 JUNE-84
ICE EDGE
19 JUNE 1984
AXBT
●SONO
ICE EDGE
26 JUNE 1984
OAXBT
●SONO
ICE EDGE
AXBT
18 JULY 1984
Loose ice
Loose ice edge
AXBT
4 JULY
10 n m

Fig. 1

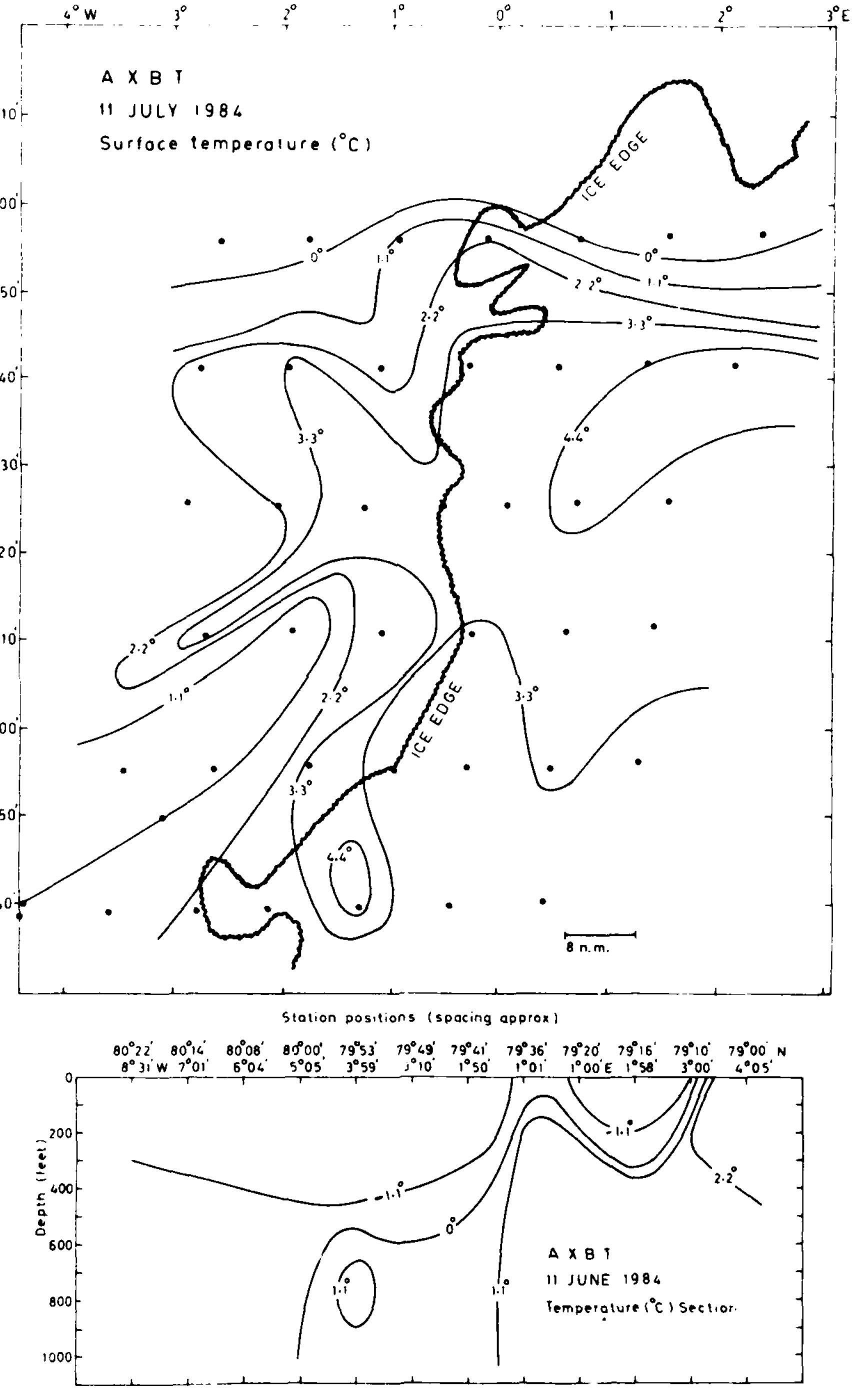

A X B T
11 JULY 1984
Surface temperature (°C)
ICE EDGE
ICE EDGE
8 n.m.
Station positions (spacing approx)
80°22' 80°14' 80°08' 80°00' 79°53' 79°49' 79°41' 79°36' 79°20' 79°16' 79°10' 79°00' N
8°31'W 7°01' 6°04' 5°05' 3°59' 2°10' 1°50' 1°01' 1°00'E 1°58' 3°00' 4°05'
Depth (feet)
A X B T
11 JUNE 1984
Temperature (°C) Section

Fig. 2

ICE

ICE RECONNAISSANCE BY THE DANISH METEOROLOGICAL INSTITUTE'S ICE PATROL

Ole Mygind

25/5 Departure cancelled owing to the weather in Narsarsuaq.

26/5 Departure from Narsarsuaq at 1440Z. Radar ice reconnaissance along the west coast to north of Fredrikshåb, and directly to Søndre Strømfjord, arrival at 1758Z.

27/5 Departure from Søndre Strømfjord at 0951Z, directly to Diskobay, and then ice reconnaissance to Thule. The weather in Diskobay was bad, there was limited visibility, mostly on radar. North of Umanaq-fjord it cleared up, and the rest of the way to Thule the weather was fine. Arrival at 1416Z.

28/5 Departure Thule at 1307Z. At departure the plane was filled up with goods to Kap Moltke and Station Nord, mostly vegetables and post, and "the important radio part" which turned out to be hi-fi equipment for Station Nord. The journey from Thule went past Herbert Ø, through Kane Basin, Kennedy Channel where we went to look at Hans Ø, further through Robson Chanal, and then along the north coast to Kap Morris Jessup. The weather on the flight was nice, which also appears on the ice charts. From Kap Morris the journey went directly to Kap Moltke, where we, after a few overflights landed at 1817Z, and departed at 1917Z and arrival at Station Nord at 2018Z.

29/5 From Station Nord we departed at 1015Z. We flew directly to Henrik Krøyers island, which, in spite of low clouds was found. There was broken winter ice around the islands, and a thin layer of snow covered the islands, no pressure ridges. From there we flew directly to the observation area for MIZEX. The weather in the observation area was very bad, low clouds all over the area, and fog over the ice, so the visual observations were bad, even when the altutude was no more than 200 feet. The observation area was covered as suggested, ice charts were drawn and a video-film recorded. From the observation area we flew directly to Longyearbyen, arrival at 1500Z.

30/5 The communication was difficult, because the strike of the telephone communication personel in Norway was just finished, and it was difficult to get the information about the weather in Greenland, especially because the information was not requested in advance.

The meteorologist at the airport had to suffice the whole day, and the only information we got was that the weather was very bad at Mestersvig, but later in the day it would clear up at Station Nord. At 1540Z we departed from Longyearbyen with arrival at Station Nord at 1823Z after a flight with heavy low clouds.

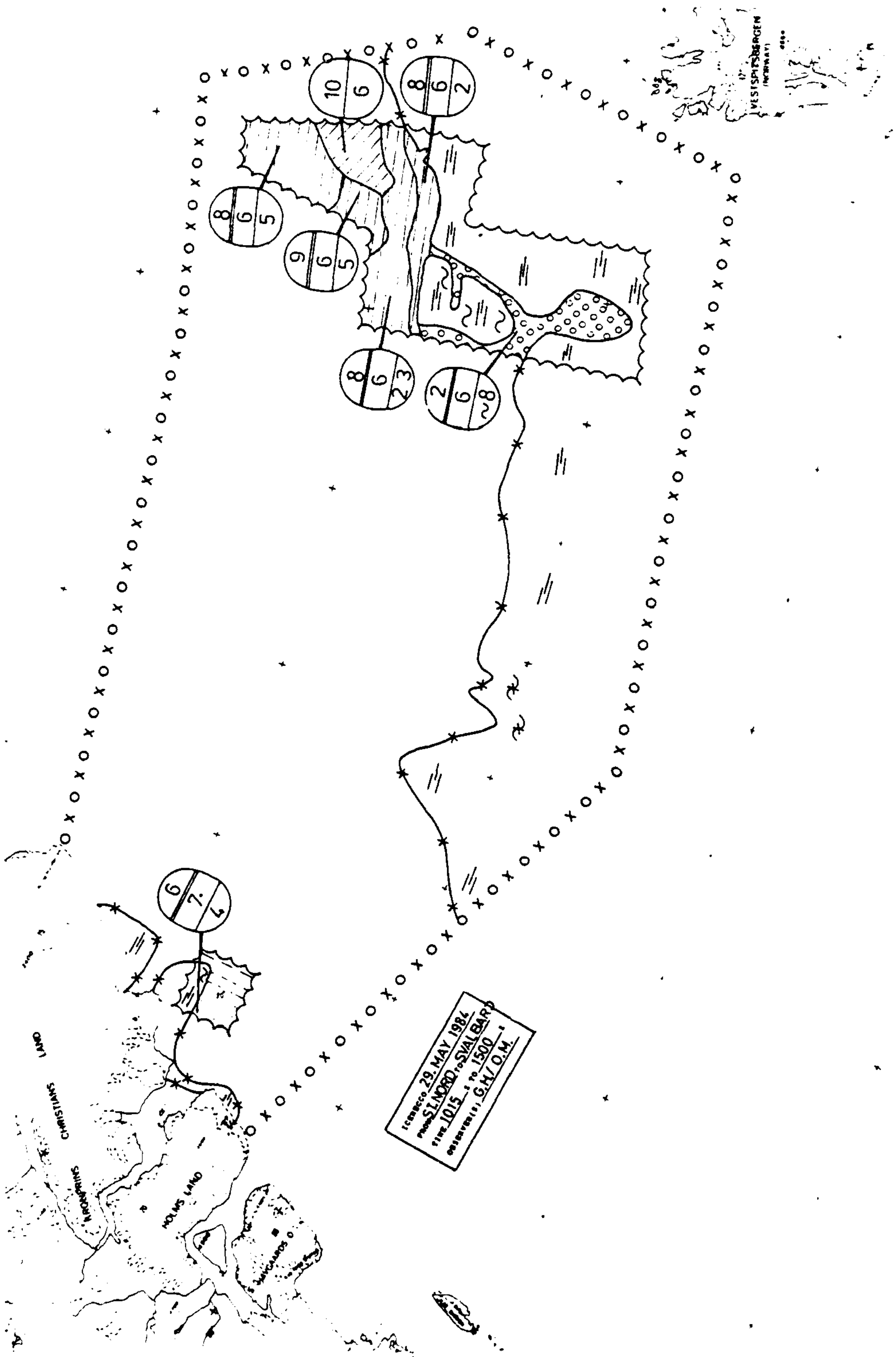
31/5 Departure from Station Nord was settled to 0800Z, but because of icing of the plane, the departure was delayed until it was cleaned. Mestersvig airport was closed because of water on the runway and bad weather, so it was decided to go home via Thule and Søndre Strømfjord. We departed at 0935Z and flew directly to Thule, arrival at 1405Z.

After refuelling we departed for Thule at 1529Z to Søndre Strømfjord via Upernavik, which expected ship arrival on 4-6. June. Ice reconnaissance was sucessful as the weather was nice along the coast. Arrival in Søndre Strømfjord at 2019Z and after fuelling departure at 2113Z, with arrival at Narsarsuaq at 2343A.

CONCLUSIONS

Because of the ice condition this time of year, it was too long to keep the Twin Otter away from the primarily reconaisance area, and there have been some complaints about this.

This time of year it is almost impossible to prepare flights over a long period as the weather is very unstable, and the runway conditions in North Greenland are dependent on the surface melt condition. If the Meteorological Institute decides that the ice central should do this kind of reconnaissance, we have to ask that a skilled person from the institution that wants the flying done, is present at the landing to judge the results, as it is not satisfactroy to do a job without knowing whether the intentions have been fulfilled.


29 MAY 1984
ST.NORD
SVALBARD
1015
1500
G.H./O.M.
CHRISTIANS LAND
HOLMS LAND
VESTSPITSBERGEN

MESOSCALE ICE DRIFT FROM ARGOS BUOYS

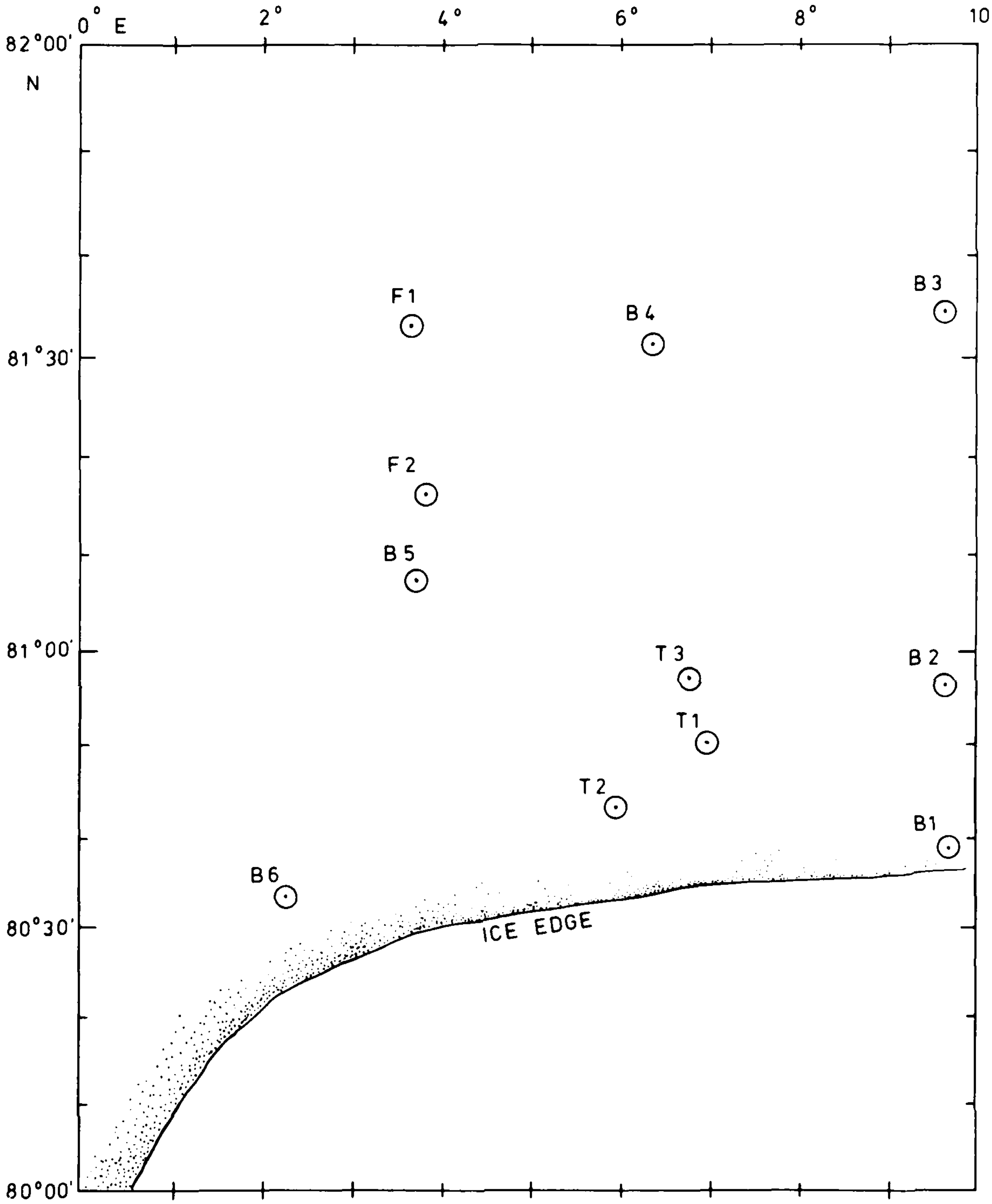
O.M.Johannessen and Brian A.Farrelly
MIzex Bergen Group *,Geophysical Institute,Univ. of Bergen

The MIZEX Bergen Group deployed 9 Argos tracked buoys during MIZEX 84. Three of them T_1 - T_3, see Fig. I which shows the initial deployment, were toroides from which current meter rigs and meteorological sensors were deployed. In addition T_2 was equipped such that the current meter measurement were interfaced and transmitted via the Argos system. The six remaining buoys B 1 - B 6 reported position apart from B 4 which reported air temperature and atmospheric pressure. B 4 was also equipped with current meters. Deployment commenced from R/V Polarqueen on 6 June and was completed on 8 June.

However, the predominantly northernly winds brought those buoys near the edge (T1, T2, T3 and B1) so close to open water that they were at risk. Redeployment was therefore necessary and for T2, T3 and B1 repeated redeployments proved necessary. Polarstern, Kvitbjørn and Haakon Mosby assisted in these operation.

Those buoys together with the rest of the 45 or so Argos buoys deployed on ice or as open ocean surface drifters were tracked at MIZEX Coordination Center, Tromsø. Tapes containing the positions and data up to the end of August have been received in Bergen and processing is planned to start shortly

* MIZEX Bergen Group: O.M.Johannessen, J.A.Johannessen, E.Svendsen, B.Farrelly, S.Sandven, T.Olaussen, S.Myking and A.Revheim.



0° E
2°
4°
6°
8°
10°
82°00' N
81°30'
81°00'
80°30'
80°00'
F1
F2
B1
B2
B3
B4
B5
B6
T1
T2
T3
ICE EDGE

Figure 1.

BEDFORD INSTITUTE OF OCEANOGRAPHY BUOY PROGRAM

G. Symonds

As part of the MIZEX 84 field program sea ice exiting through Fram Strait was "seeded" with satellite tracked buoys. The objective of this program was to obtain estimates of the spatial and temporal variability of the mean and variance of summer ice drift through Fram Strait. In addition three buoys were equipped with anemometers to allow estimates of the wind driven component of ice drift to be made.

A summary of the data obtained is given in Table 1. At the beginning of the MIZEX 84 field program six buoys were deployed across Fram Strait as shown in Figure 1. Approximately three weeks later a further four buoys were deployed in the same geographic area. Deployment dates and positions are shown in Table 1. Two additional buoys were air dropped by the Norwegian Air Force to extend the spatial coverage further to the west. However, both of these buoys failed to operate.

Except for the failure of the air dropped buoys and compass problems with one anemometer buoy this experiment was successful with a total of 533 buoy days of data obtained as of September 15, 1984.

Shown in Figure 1 are the trajectories obtained from the first buoy deployment for the month of June. The data shown in the figure represents about one quarter of the total data set. At the time of writing this summary the remaining data had not arrived from Service Argos.

Acknowledgements

I take this opportunity to express my thanks to M. McPhee and R. Lindsay on Polarqueen, E. Augstein and O. Johannessen on Polarstern and the crew of the Norwegian P3 for deploying the buoys for me during the MIZEX program. I also express my thanks to the crew of Kvitbjorn who stayed and recovered two of my buoys after everyone else had gone home.

TABLE 1

Buoy No.	Deployment Day	Deployment Latitude	Deployment Longitude	Measurement	Buoy Days	Comments
2346	158	80 00N	00 20E	Position	101	Still Active
2408	158	80 42N	00 07W	Position	34	Lost
2342	158	79 52N	00 16W	Pos., Wind Sp., Direction	29	Lost
2409	158	80 16N	01 30W	Position	78	Lost
2340	158	80 28N	03 17W	Pos., Wind Sp., Direction	65	Lost
2347	158	80 39N	06 07W	Position	34	Recovered
2343	163	80 30N	10 00W	Position	None	Air Drop
2348	180	80 04N	00 08W	Position	26	Recovered
2345	180	80 16N	01 36W	Position	81	Still Active
2341	180	80 20N	03 08W	Pos., Wind Sp., Direction	25	Recovered
2407	181	80 39N	05 34W	Position	60	Lost
2344	186	80 30N	10 00W	Position	None	Air Drop

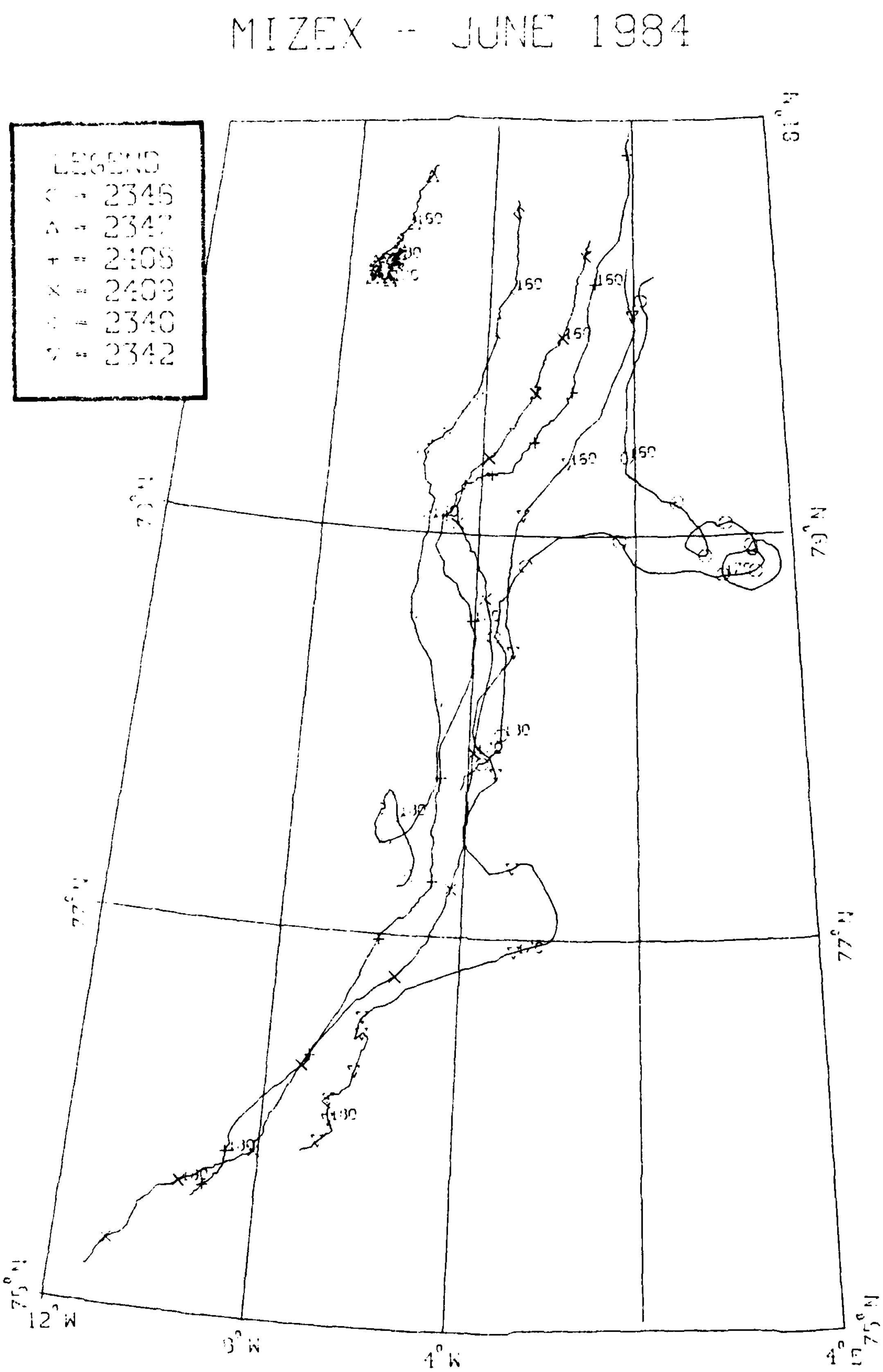


Figure 1.

MIZEX 84 MESOSCALE SEA ICE DYNAMICS: Post Operations Report

W.D. Hibler III[1], M. Lepparanta[2], S. Decato[1], K. Alverson[1]

1. USA CRREL, Hanover, NH 03755
2. Institute for Marine Research, Helsinki, Finland

This report summarizes the basic characteristics of the mesoscale sea ice dynamics data set taken from the Polar Queen, which was the main drifting station during the MIZEX 84 experiment in the Fram Strait region. The main purpose of this deformation experiment was to precisely measure mesoscale deformation and floe rotation characteristics in order to learn more about the rheology and dynamics of the interacting ice field in the marginal sea ice zone. This can be accomplished by comparing the fluctuation and rotation data with theoretical and numerical calculations, and by using the deformation data to verify more complete ice dynamics simulation models.

The basic data set consists of precise (~ 1 m relative accuracy) position measurements made at 15-minute intervals of microwave transponders located at as many as five sites from 2 to 18 km from the ship. The angles are determined less accurately by triangulation. Data acquisition was automated with an Apple II computer programmed up to automatically acquire data via a communications line connected to two master ranging units on the flying bridge. These data were printed and recorded on magnetic disc at 15-minute intervals. In addition, during most of the experiment the rotation of at least one of the floes supporting a transponder was monitored at 15-minute intervals by using two transponders about 50 m apart on that floe. Because of the different locations and drift of the Polar Queen, the data set is particularly complete, and comprises over 30 days of deformation data acquired both in the interior of the marginal ice zone and near the ice edge. In addition, a variety of floe sizes and compactness conditions were sampled. Overall, the data set can be separated into 3 phases (see Fig. 1). Phase 1 covers the period 9 to 16 June, during which the Polar Queen was moored to a floe near the ice edge. This floe finally disintegrated on 16 June and the ship was moved to a larger, thicker floe further into the pack, where it remained for the duration of the experiment. During this first phase the ice was very mobile and dynamic, with substantial deformation and drift occurring. This in turn necessitated relocation of two sites before the whole array was brought in on 16 June. In particular, unit 72 was moved from site N3 to site N3B on 13 June, and unit 74 was moved from N1 to N1B on 14 June (see Fig. 3).

During the second phase of the experiment from 17 June to about 6 July the ice was much more compact, and the deformation, except for relatively major deformation events every week or so was much less pronounced. During this phase the ice was mostly "locked together," with smaller fluctuations occurring. Three transponders had to be redeployed in this phase, mainly due to intense ice ridging which occurred on 3 July at site C1 where two transponders were located. This deformation destroyed two tripods, knocked one of the units into the water, and bent an antenna on another. However, after being recovered the Del Norte transponders were found to still work fine, and were moved to new, separate sites (N3 and C1A). The transponder at N1 was also moved to N4 on 4 July to obtain a better areal coverage.

Toward the end of this second phase the deformation began to pick up as the ice became less compact. As a consequence, most of the units finally drifted out of range and the whole array was redeployed on 12 July as a 3-site array with two transponders at two floe locations for more complete floe rotation measurements. This array too rapidly diverged until it was picked up on 16 July with some of the units out of triangulation range.

To make distance measurements with this transponder system, the distances to a site from the ship and from a "slave" triangulation site located at one of the transponder sites were simultaneously measured. This information alone allows the x-y positions of the array in a rotating coordinate system to be determined and, hence, the strain rate invariants to be determined with considerable accuracy. To locate the orientation of the array in absolute space, angular measurements to a passive radar transponder at the slave site were made at 8-hour intervals using the ship's radar.

A particularly valuable feature of this array is that it can be ranged from using a helicopter-mounted master unit. By using an inverter to run an HP computer which in turn controlled a master ranging unit in the helicopter, it was possible to "home" in on the radar transponder and retrieve it after it had drifted either out of range or at least out of triangulation range. This was effectively used at the end of phases 2 and 3 to retrieve units which otherwise might well have been lost. Amazingly enough, despite the very dynamic deformation conditions, no equipment was lost during this experiment.

The actual mounting of the transponders on the ice made use of a collapsible tripod system designed by Dave Fisk of CRREL (see Fig. 2). This proved most durable and was found to be very easy to relocate, as it could easily be slung fully assembled by helicopter. Oversized batteries contained in insulated wooden crates and quick battery disconnects were used to power the units. They were left up to 9 days at sites without ranging failure. The only man-made problem encountered was a bad battery connection at the slave site, which prevented triangulation data from being obtained for about 1-1/2 days during the second phase. The other problems were drifting out of range, bear attacks on equipment, and ridging. Although floes did break apart, this did not affect any transponders.

Fig. 1 presents an overall chart of data taken and is organized by transponder unit number. In the table, RL refers to a "range loop" measurement which essentially gives the distance from the "slave" site. Gaps (other than occasional one- or two-reading data dropouts) are indicated but not annotated with details (bears, deformation, out of range, etc.). Site coding is noted and can be compared to the scale drawings of transponder locations at various times throughout the experiment in Fig. 3.

To give a feeling for the actual time series data required, Fig. 4 shows a time series plot (on the Apple printer) of distance to unit 86 at the end of phase 2 and beginning of phase 3. The later high deformation shown is very similar to that experienced during phase 1.

Overall it is felt that this data set represents a unique set of measurements of the deformation field of a series of interacting ice floes. Because of the fine temporal resolution, accuracy of the measurements, and coincidence of current and wind measurements, these data should greatly aid in understanding the physics of marginal ice zone dynamics.

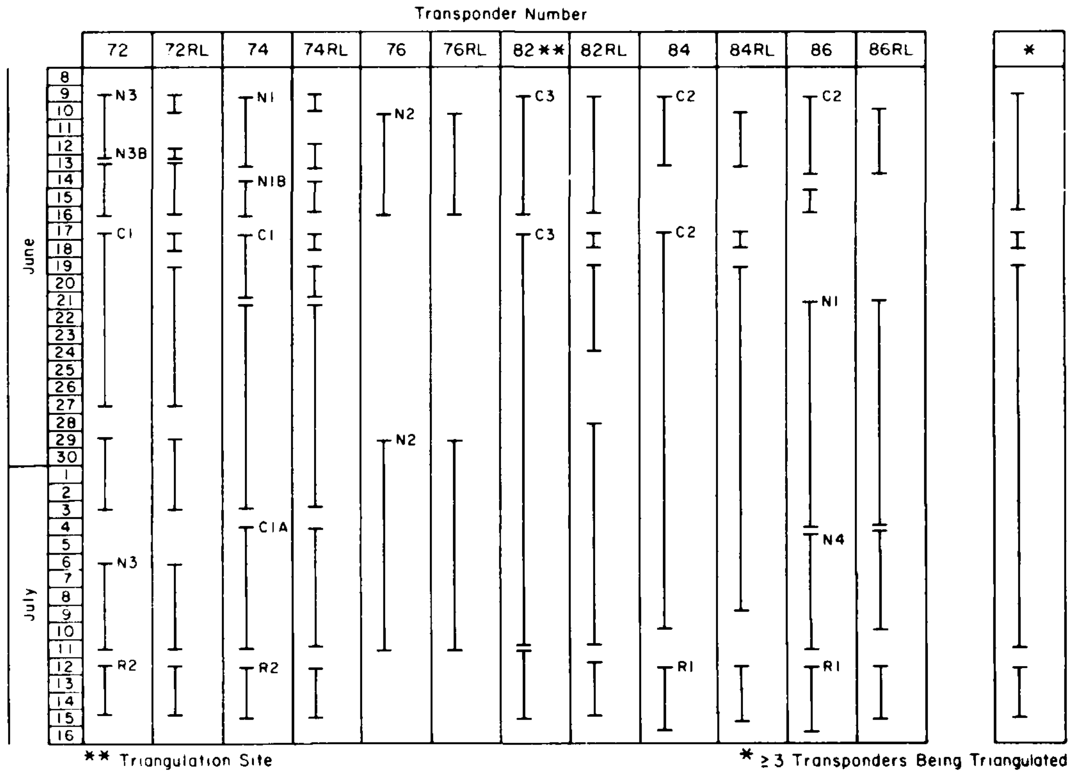


Figure 1. Deployment chart for transponders. The chart shows times when direct measurements and range loop measurements (denoted by RL) were made at 15-min intervals to transponder unit numbers 72, 74, 76 and 82, 84, 86. For range loop measurements, a slave unit was located at site 82. (The range loop measurement to 82 is redundant as it effectively gives an additional but unneeded distance measurement to unit 82 from the ship.) Also denoted on the chart is the location of the unit with reference to Fig. 3.

Figure 2. Transponder tripod fully deployed. This picture was taken by Buddy Mockford on 29 June after unit 76 was deployed at site N2. For scale, Bill Hibler, on the right, is 6'6" (1.98 m) tall and Steve Decato, on the left, is 5'8" tall.

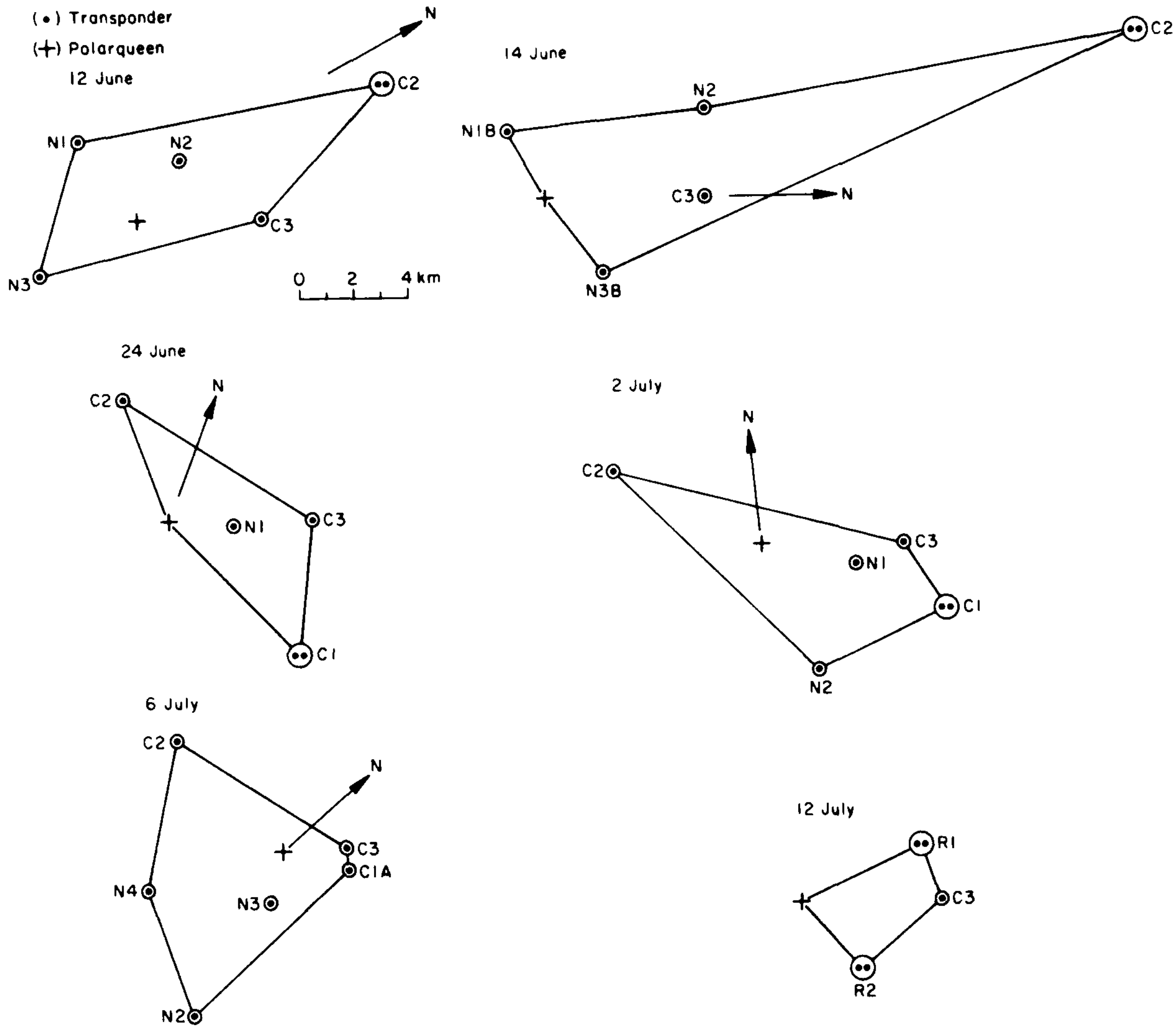


Figure 3. Scale drawings of the array configuration at representative times throughout the experiment.

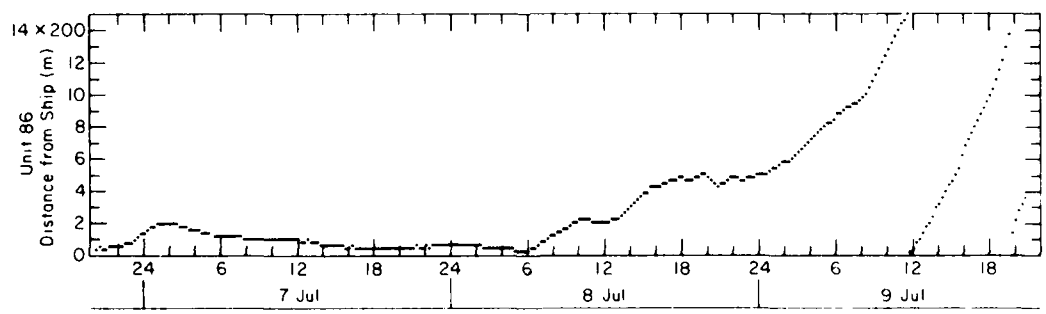


Figure 4. Time series of distance measurements to unit 86 located at site N4. The resolution here (40 m) is dictated by the printer used for the plot. The actual distance measurements are accurate to 1 m and are recorded to the nearest 0.1 m. Distances are plotted modulo 3000 m. The initial distance was slightly greater than 6000 m.

SCOTT POLAR RESEARCH INSTITUTE PROGRAMME ON ICE EDGE KINEMATICS, WAVES AND AERIAL PHOTOGRAPHY DURING MIZEX-84

P. Wadhams, V.A. Squire and A.M. Cowan

1. Ice edge kinematics. The motion and deformation of the ice cover near the margin were measured during three "minidrift" experiments, in which arrays of radar transponders were tracked from ships. The first minidrift was carried out from "Polarstern" during June 22-25. The ship positioned herself at 80°14'N, 3°E, about 8 n ml from a diffuse ice edge and close to two Bergen toroid buoys (5062, 5064) equipped with weather stations and current meters at 5, 10 and 40 m depth. Four SPRI buoy sites were set out, each site comprising a radar transponder and reflector, a "Seadisc" one-dimensional telemetering wave buoy and an Aanderaa current meter at 10 m depth. At the same time 6 radar-radio buoys were set out in the ice edge region (1-2 n ml from edge) in a joint programme with H. Ito (Alfred-Wegener-Institute) to study extreme edge phenomena such as longshore jets. The arrays were tracked for 3 days, with remote sensing coverage via helicopter photography (A M Cowan), CV990, NOAA P-3 and Falcon overflights. On the second day the wind direction changed radically from off-ice (N) to on-ice (SE). The drift direction of the array changed to keep the mean drift at about 40° to the right of the wind, but also the ice edge became more compacted with the array flattening along an axis at right angles to the ice edge and stretching in the along-edge direction. After compaction, the whole array gradually approached the ice edge, the rate of approach being a measure of the lateral erosion of the edge from wave-induced breakup and melting

The second minidrift began from "Polarstern" early on July 3 and ended from "Kvitbjørn" late on July 7. "Polarstern" began her drift at 80°26'N, 1°20'E, some 15 n ml inside the ice edge and 15 n ml from "Polar Queen". The aim was to couple the ice edge array to "Polar Queen's" interior array, with one transponder being tracked from both ships. An array of 4 SPRI buoys and 4 Ito buoys was set out. The ice edge was compact, with some vast floes near the edge, and with a possible eddy feature comprising a deep inlet extending several miles into the ice (investigated with CTD surveys by "Valdivia" and "Kvitbjørn"). The two Bergen toroids were deployed by "Kvitbjørn" close to the array, to provide additional wind and ice-water velocity field data. The array moved southward initially, with some anticyclonic rotation and a stretching as the buoys furthest to the S and W began to experience a strong ice edge jet running to the SW. Late on July 4 "Kvitbjørn" moored to a floe near "Polarstern" and deployed a meteorological mast and tethersonde (BIO and AES). "Polarstern" then transferred SPRI personnel (except Cowan) and, after recovery of Ito buoys, the tracking of the SPRI array continued from "Kvitbjørn". After another 20 hrs of southward drift, the array, now close to the ice edge, began to move rapidly to the SW, driven by the ice edge current jet and a N wind. During the next 48 hours the array drifted 32 n ml ending at about 79°50'N, 1°W. Little further rotation or deformation occurred during this period. Recovery of the array took place late on July 7. Remote sensing coverage during the drift came from helicopter photography (from "Polarstern" and "Polar Queen") and the NOAA P-3.

The third minidrift took place from 17-21 July, on the south side of the prominent ice tongue associated with the semi-permanent Fram Strait eddy. "Kvitbjørn" set out 3 SPRI buoys then positioned herself at 79°09'NW0°W to begin tracking. A fourth buoy was set out on the following day. Fig. 1 shows the drift and deformation of the first 3 buoys. Initially this consisted of pure anticyclonic rotation at a rate of 1.4 rad day^{-1}, a measure of the vorticity of the eddy itself. Then the rotation slowed and the array moved SE, flattening itself out along the ice edge: the entire eddy appears to have changed shape so that the array drifted into a region where it was more affected by the normal drift of the East Greenland Current and less by the eddy vorticity. Further interpretation awaits analysis of satellite and aerial imagery. Two of the SPRI

buoys were set up beside Bergen toroids, equipped as before. Aerial photography of the array was provided by "Polar Queen's" helicopter; recovery after 3 days was done by ship.

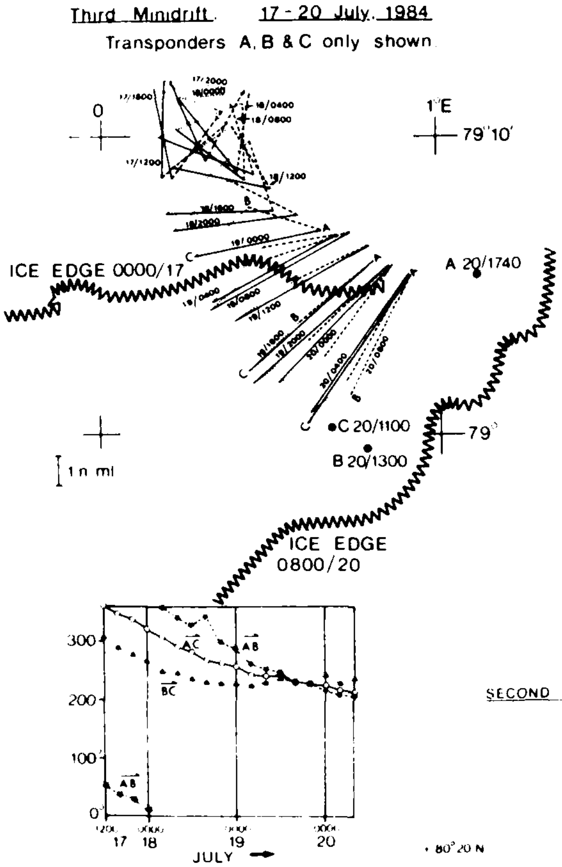
2. Waves programme. The waves programme was designed to measure the directional wave spectrum inside and outside the ice edge, so as to determine the effects of reflection and refraction as well as attenuation. During June 16 to July 2, 16 stations were occupied from "Polarstern", comprising a 5-station helicopter "floe hopping" experiment, where a heave-tilt sensor was deployed on floes at 10 km intervals along a line moving into the ice; and 11 single stations using the heave-tilt sensor, a Seadisc or an Endeco Wavetrack directional wave buoy, to support remote sensing overflights or open water stations carried out by "Valdivia". From July 4 onwards a more concentrated programme from "Kvitbjørn", carried out in co-operation with Institute of Oceanographic Sciences (R. Pascal), involved some 60 stations using the IOS pitch-roll buoy, the Endeco and the heave-tilt sensor. A typical line of stations would comprise buoy deployments at 10, 5, 2, 1, 1/2 and 0 n.ml. outside the ice edge followed by heave-tilt stations on floes as deeply into the ice as "Kvitbjørn" could penetrate. 5 lines of this type were done. In addition 2 band experiments were done, in which buoys were deployed to windward, leeward and beside prominent ice edge bands, to study the effect of wave radiation pressure on band dynamics.

In an associated programme, E. Josberger (USGS) deployed sensors to measure bottom ablation and wave-induced sidewall ablation of floes. To measure the modification of the upper ocean structure associated with the resulting meltwater, S. O'Farrell (SPRI) operated a mini-CTD from floe edges and in leads (using "Kvitbjørn's" motorboat), down to 80 m depth.

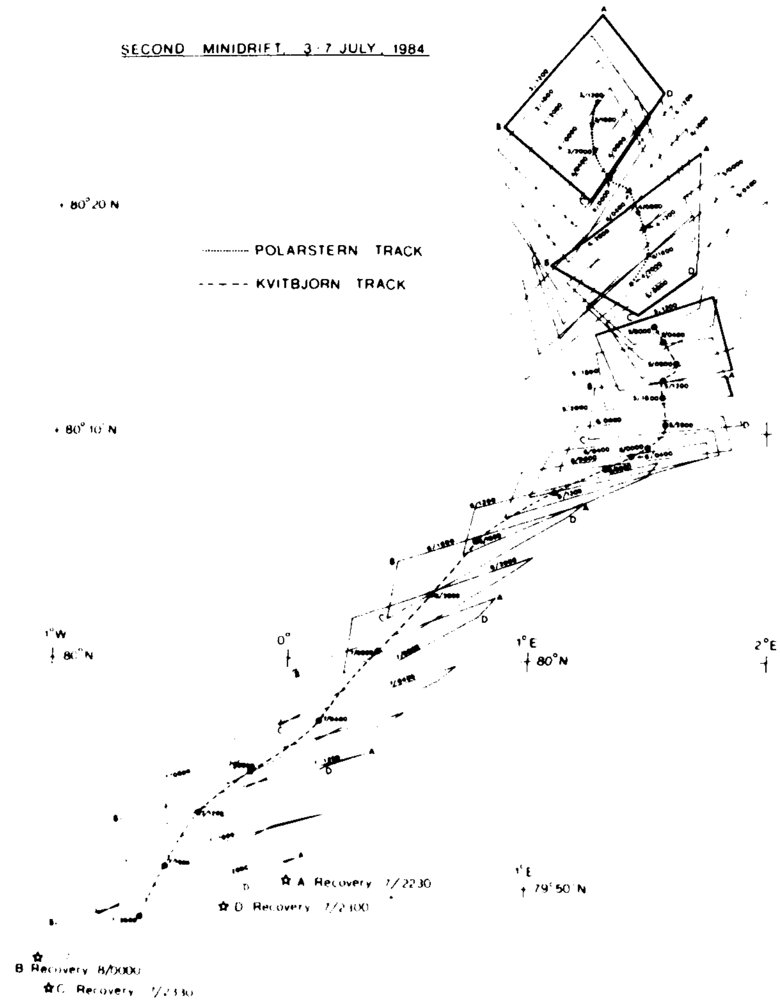
3. Aerial photography programme. The SPRI Vinten F95 reconnaissance camera was used in conjunction with video filming to obtain a total of sixteen aerial photographic datasets in support of various experimental programmes. In sum approximately 5000 frames of vertical photography are suitable for analysis. The list that follows indicates the purpose of each dataset:

Video 1	14 June	ice reconnaissance support
Vinten 1, Video 2	15 June	as above
Vinten 2, Video 3	15 June	wave attenuation experiment 1
Vinten 3, Video 4	17 June	" " " 2
Video 5	18 June	CV990 overflight support, re: radar altimeter
Vinten 4, Video 7	22 June	scatterometer support, re: R. Onstott
Vinten 5	22 June	as above
Vinten 6	23 June	first mini-drift transponder array overflight
Vinten 7	23 June	ice edge to ship, re: floe size distribution
Vinten 8, Video 9	24 June	mini-drift transponder array overflight
Vinten 9, Video 11	28 June	CV990 and scatterometer support
Vinten 10, Video 12	30 June	CV990 support
Vinten 11, Video 12+13	2 July	Fram Strait eddy transects
Vinten 12	3 July	second mini-drift transponder array overflight
Vinten 13	4 July	as above
Vinten 14	4 July	as above
Vinten 15	9 July	scatterometer support and SAR-580 support
Vinten 16	13 July	intensive aerial coverage of 5 x 5 n ml box forward of Polarstern for surface roughness measurements re: meteorology of boundary layer (C. Wamser)

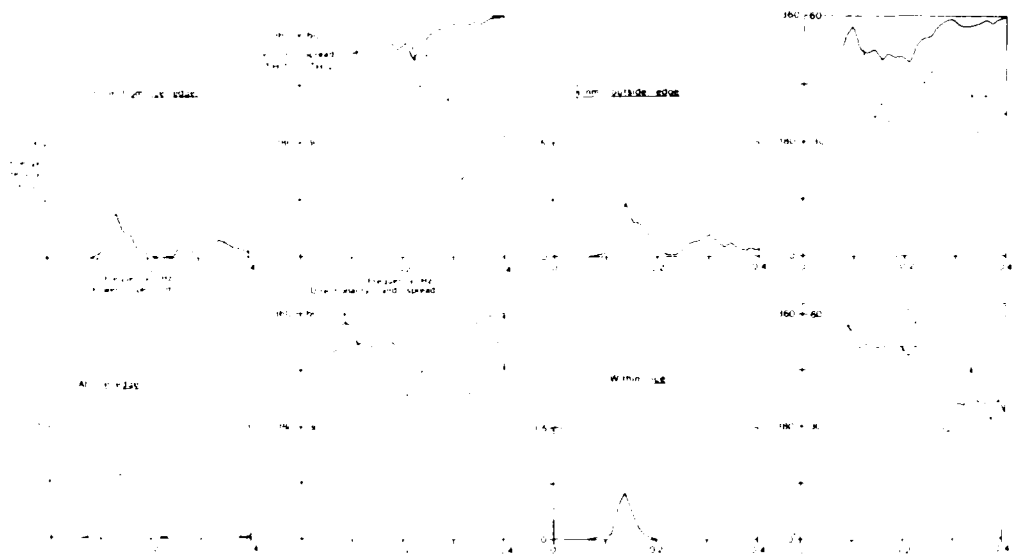
The statistical analysis of the above datasets involves all two-dimensional geometric properties of the ice cover so as to yield, e.g. concentration, floe size distribution, etc. Surface roughness estimates may be made with reference to supporting surface photography.



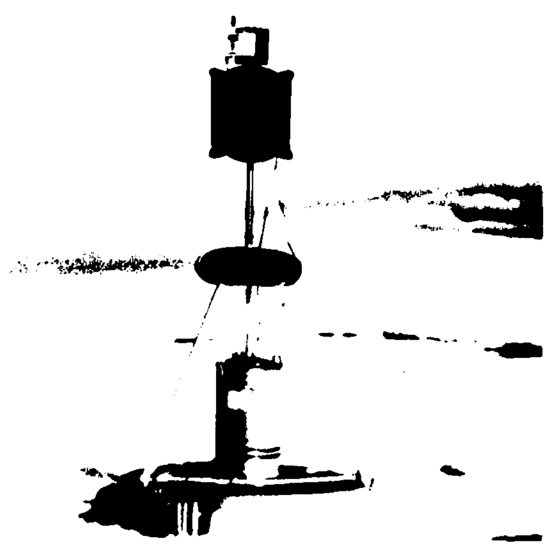
The drift tracks of three of the four transponders deployed in the third minidrift showing the cyclonic rotation of the Fram Strait eddy followed by a flattening along the ice edge. The inset shows the change in bearing of the three sides of the triangle.



The drift tracks of four transponders and of the "Polarstern" and "Kvitbjørn" during the second minidrift. Dark black lines show the new shape of the array immediately after repositioning of one or more transponders.



Power and directional spectra showing the evolution of a directional sea impinging on the Fram Strait ice edge. Each pair of graphs represents 37 minutes of data recorded at a different location, viz. 5 nml from edge, 0.5 nml from edge, at edge, and within the ice cover. Although the power spectral density changes little until the ice is entered, except for a slight lessening of the short period sea, the directional composition alters markedly.



The radar transponder buoy used in the tracking experiments. Each buoy comprises a transponder, a radar reflector, a Seadisc wavebuoy, a radio beacon, batteries, and flotation.

Extreme Ice Edge Ablation Studies

Edward G. Josberger, U.S. Geological Survey

The extreme ice edge ablation studies took place during the second portion of MIZEX 84, 3 to 20 July 1984, the instrumentation deployed from Kvitbjorn. The goals of the program were to measure the bottom ablation in coordination with the ice-edge phenomena study and to measure the wave field in the leads as it relates to waterline ablation. A complete understanding of the bottom ablation requires the melding of this data set with the current-meter measurements made at each toroid site by the Geophysical Institute, University of Bergen.

On 3 July 84 during the 2d minidrift USGS deployed 3 acoustic bottom ablation gauges, one at each of the 3 Toroids deployed by the Geophysical Institute. When Kvitbjorn took over the minidrift from Polarstern, USGS deployed an acoustic bottom ablation gauge, and one current meter 7m below the ice at the center of the drift site. Also, periodically during the drift phase, a capacitance wire wave gauge measured the shortwaves in the adjacent leads.

On 7 July Kvitbjorn recovered all of this instrumentation. The bottom ablation records show little melting for the first two days but for the latter two days the melt was approximately 10-20 cm day^{-1}. The increase in ablation resulted from the ice drifting into warmer water which was shown by the CTD costs throughout the period.

During the ice edge phenomena study from 9 July to 13 July a bottom ablation gauge was deployed in conjunction with a Geophysical Institute toroid and current meters in an ice tongue. The Toroid was recovered on 13 July floating free in scattered ice. The ablation record showed that the ice had melted by about 40 cm before breaking up. The floe broke up approximately 24 hrs before recovery. During this phase periodic wave measurements were made.

For the 3d minidrift, 17-20 July, bottom ablation was measured at the two Toroids and at the drift site. Also at the central drift site, a current meter was deployed at 5 m below the ice and period wave measurements were made in the adjacent leads.

During the 2d minidrift the bottom abalation increased rapidly as the ice moved into warmer water, but during the 3d minidrift the abalation was negligible as the ice remained nearly stationary in water near its freezing point. Figure 1 shows a representative record from each minidrift. The solid line is the record from the 2d minidrift, the dashed line is from the 3d minidrift.

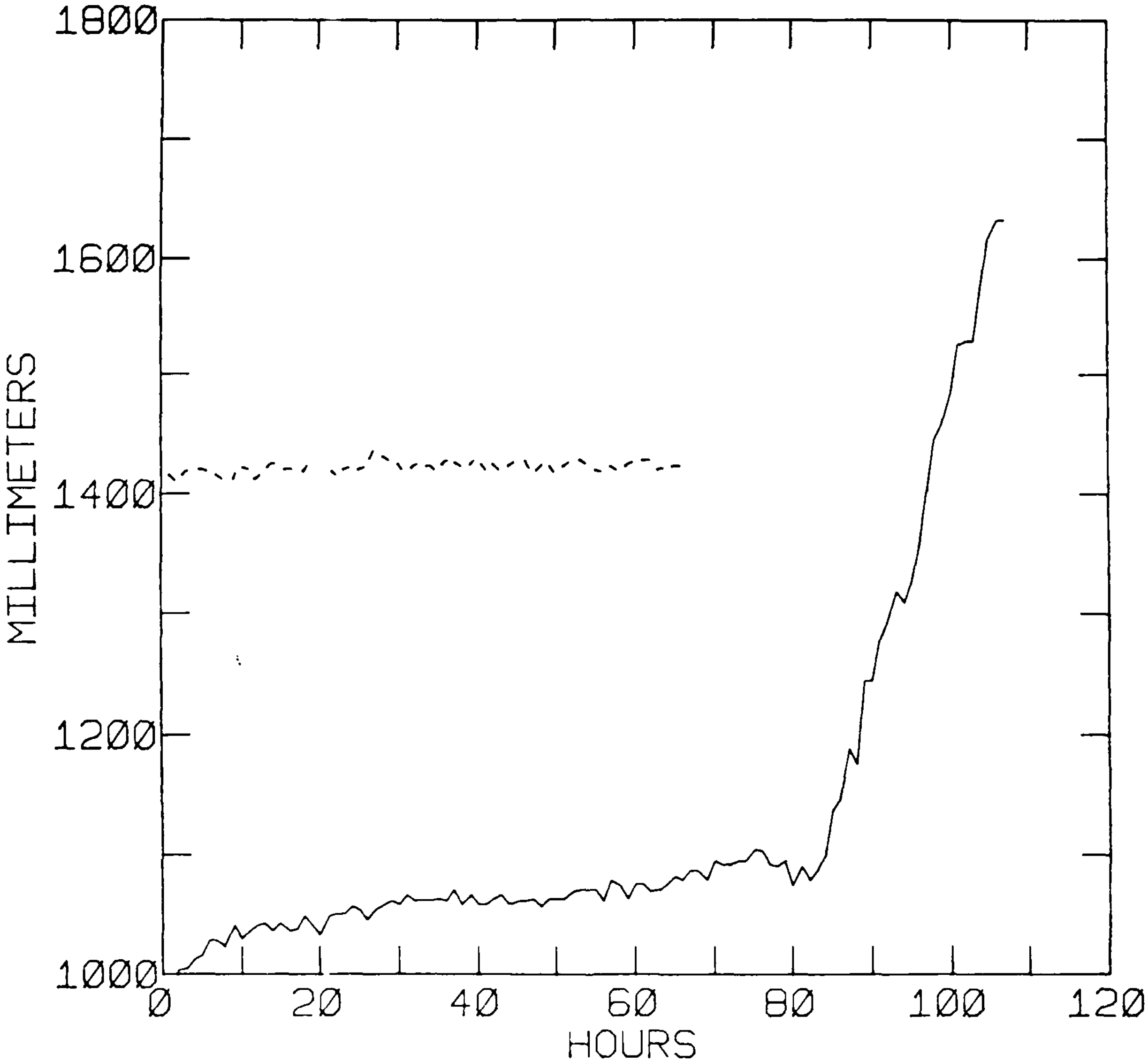

1800
1600
1400
1200
1000
MILLIMETERS
0
20
40
60
80
100
120
HOURS

Figure 1

UNIVERSITY OF WASHINGTON HEAT AND MASS BALANCE PROGRAM

Gary A. Maykut

Detailed heat and mass balance studies were carried out by University of Washington investigators (T. Grenfell, A. Hanson, D. Perovich) on two primary floes during the MIZEX 84 Drift Program. Limited observations were also made on several surrounding floes. The first floe (nicknamed "Rotten Floe") measured some 200 x 300 m across and was composed largely of first-year ice. Occupation began on 7 June and was terminated on 16 June due to breakup. The second floe ("Fallback Floe") was predominantly thicker multiyear ice and substantially larger (450 x 800 m). Measurements were carried out here throughout the remainder of the drift period (18 June-18 July).

Nine snow depth surveys were made on five different floes. Sampling grids contained 100-180 points with a grid spacing which varied between 3 and 9 m, depending on floe size. Except for the area around Rotten Floe, snow cover in the region appeared to be much heavier than in the Central Arctic: snow thickness initially averaged about 20 cm on Rotten Floe and 63 cm on Fallback Floe. Other snow data included density, free water content, grain size, temperature and salinity. Hot wire thickness gauges were used to monitor ablation on floe bottoms and ablation stakes provided data on mass changes at the surface. Bottom ablation on Rotten Floe was quite rapid (7 cm/day), but the surface actually gained mass over the 8 day period due to snowfall. Total bottom ablation on Fallback Floe varied from less than 50 cm to more than 120 cm, depending strongly on location relative to the floe edge. Beneath the interior of the floe, ablation rates averaged about 2 cm/day, while near the edge, the average rate was nearly double this. Much of this difference, however, was attributable to very rapid melting near the edge during the last 5 days of the drift and was probably associated with the decreasing ice concentration and increasing shortwave radiation input to the upper ocean. Ablation rates on small ridge keels near the middle of the floe were 50% larger than those of undeformed interior sites. Snow coverage at the end of the drift was about 20% of the floe and pond coverage 30%; superimposed ice produced by the melting and refreezing of snow accounted for roughly half the area covered by bare ice.

Ice wall profiles and lateral ablation measurements were taken at 5 sites on Rotten Floe and 6 sites on Fallback Floe. About 16 detailed profiles were obtained during the drift period, together with daily values of wall retreat at three selected levels at all edge sites. Lead width and wind direction were recorded several times a day at all edge sites. Lateral erosion at the water line varied between 1 and 10 m over a one month period, with the amount of erosion being inversely related to the ice thickness. Large amounts of brash were observed in the leads indicating that substantial mechanical erosion was taking place. Data on wave spectra were gathered in leads adjacent to both primary floes, but were complicated by frequent lead closures and the presence of brash. The wave gauge instrumentation was destroyed in early July by a marauding bear.

Several dives were made to examine the lower part of the floe walls and to carry out a photographic reconnaissance of the underside of the ice. Floe walls were characterized by numerous scallops, typically about 30 cm across and 10 cm deep. The bottom of the floe was covered by smooth undulations with a vertical scale of about 1 m and a horizontal scale on the order of 10 m. The origin of these features appeared to be ice blocks forced under the floe during earlier deformational activity. Keels on several small ridges (4-5 m) were examined and unexpectedly found to be roughly comparable in size to the sails.

Daily CTD casts were taken in various leads around the floe. Vertical resolution was 10 cm in the upper meter, 20 cm between 1 and 5 m, and 1 m between 5 and 20 m. Occasional two-dimensional profiles across leads were also obtained, as were time series at 2-4 hour intervals on selected days. The heat content of the leads remained relatively constant during much of the experiment, but increased by more than an order of magnitude during the final 9 days of the drift. In contrast to the marked stratification we previously observed in the active MIZ north of Prince Patrick Island, leads in the MIZEX 84 region were typically well mixed in the upper 5 m. The reason for this difference is uncertain but is most likely related to lower melt rates in the MIZEX area.

Incoming shortwave and longwave radiation were monitored continuously near the edge of the floe throughout the experiment. Lead albedos (both spectral and total) and extinction coefficients in the water were also measured. To determine the integrated effect of changing ice thickness and surface conditions on the transmission of shortwave radiation by the ice, vertical profiles of light intensity were taken in the water beneath Fallback Floe at 3-4 day intervals. Measurements were made in 5 wavelength bands down to a depth of 15 m. Light levels beneath the ice were observed to increase sharply as the snow cover disappeared, followed by a more gradual rise as melt pond coverage became more extensive. Downwelling spectral irradiance at the surface of the ice was sampled every 3 days and data obtained over a fairly broad range of cloud conditions. Total and spectral albedos were observed at about 20 sites which included all major ice surface types occurring during the experimental period. Two new aerial photometers were used to gather area integrated albedo data in 3 separate wavelength bands over the ice. Upward- and downward-looking photometer data were taken by helicopter in conjunction with most of the photographic survey flights near *Polarqueen*. When calibrated with ground based data, these albedos should make it possible to calculate ice concentration and melt pond coverage in the region without the need for tedious and time consuming analysis of aerial photography.

Understanding the response of the ice to thermal and mechanical forcing is a necessary prerequisite to modeling the MIZ. Because shortwave radiation is a principal agent in the summer decay cycle, the experimental work was focused on properties and processes that affect its interaction with the ice and ocean. Of particular concern was the input and distribution of solar energy in the upper ocean, and the factors that control the transport of heat from the water to the ice. When coupled with results from other MIZEX programs, the data described above should yield detailed information on the role of the upper ocean in the decay and retreat of the MIZ and should allow us to gauge its importance in relation to atmosphere-ice interactions.

HELICOPTER PHOTOGRAPHY OF ICE CONDITIONS

D.A.Rothrock

The helicopter photography conducted from the *Polar Queen* during MIZEX 84 can be categorized by three different flight patterns:

1. Transects from the *Polar Queen* to the ice edge for the purpose of measuring ice conditions and floe size distribution. Typically these flights were at 3,000'; the lowest altitude for a transect was at 800'. The planned flight paths were along bearings of either 180° or 150° from the *Polar Queen*.

2. Mosaics of an area 5 km square centered on the *Polar Queen*. These were also intended to provide ice concentration and floe size distribution and, in addition, floe breakup information. Most of the mosaic flights were at altitudes between 2,000' and 2,700' which kept the number of frames at a manageable level and still resolved 1-2 m floes.

3. Photos of individual floes to measure the lateral melt back and erosion. A surveyed array of targets was put on each floe to calibrate the measurements. The floes were typically the C and N sites of the small buoy arrays.

An additional division in the data is between the two drift locations the *Polar Queen* occupied. The first period of photography was from 7 June to 14 June. There were four transects and two mosaic flights during this phase. Some of these were abbreviated because of teething problems with the equipment. One short sequence of lateral melt photos exists during this period.

The second drift period's photography started on 19 June and ran with reasonable frequency (2-3 days) until 5 July, when persistent fog and low ceilings severely curtailed the photo program. The last mosaic and transect were on 9 July. A total of 8 mosaics and 7 transects were acquired. The lateral melt photos ended on 12 July. There are sequences of five floes for periods of 9 to 15 days. This part of the experiment was marred by the discovery of an intermittent and undetected shutter malfunction in the mapping camera, which reduced the number of useful lateral melt photos by about half.

During much of the transect and mosaic flights, three channel upward and downward looking photometry data (Grenfell) were recorded in conjunction with the photography. On two occasions photography was taken for SPRI in the vicinity of the *Kvit Bjorn*.

The MIZEX-84 High Frequency Accelerometer Study

Paul K. Becker and Seelye Martin

The field portion of the MIZEX-84 high frequency accelerometer experiment began 29 May in Bergen, Norway, with the loading of 2500 pounds of equipment onto the Polar Queen. The shipboard equipment occupied half the space in one of the mobile trailers in the main hatch of the ship. Sailing time from Bergen to Tromso and from Tromso to the edge of the ice pack was used to mount the telemetry antennas and set up the equipment.

The object of the experiment was to count and estimate the strength and direction of bumps incurred by three sample floes in the interior of the MIZ. A ten foot long cylindrical buoy with an attached float was deployed on each floe (Figure 1). The buoys each contained three accelerometers mounted at right angles to one another, an Aanderaa compass, and a battery driven electronics package made at the University of Washington. That package translated the voltages from the accelerometers into FM tones which were transmitted twenty minutes per hour to the data collection system on the Polar Queen. The compass was sampled once an hour. The data collection system on the ship consisted of an antenna and preamplifier connected to a demodulator which fed the three voltages per buoy to an A/D convertor. The TECMAR A/D board was controlled by a Texas Instrument Professional computer. The microcomputer also buffered data (8 samples per second for x and y dimensions, 2 per second for z) and then stored the data on a Tallgrass 20MB hard disk. Ten minutes of data per hour was to be saved in this way for fourteen days. Twenty minutes of data per hour for eight days was to be recorded in tone form on a Revox SLS tape recorder as a backup data bank.

In the field study, buoys were initially deployed on floes T3, C3, and C2 (floes which also held the CRREL Del Norte radar transponders for accurate position data). It was soon found that buoys completely assembled except for antenna could be slung by helicopter for quick deployment and recovery. Data collection began June 8. Due to shear and/or eddy conditions during the next eight days, buoys several times moved out of telemetry range of the ship. Two helicopter redeployments kept at least two of the buoys within range at all times. Data collection was interrupted at midday on 16 June when the drift floe moved to the edge of the MIZ and broke into pieces. The ship sailed back into the MIZ and all three buoys were redeployed on C1*, C2*, and C3* around the second drift station. Data collection then continued from 18 June to 25 June. Sixteen and a half days of digitized data (25 MBytes) and 12 days of analog data were collected all told. All equipment was successfully recovered: one buoy case was damaged but the guts of that buoy were unhurt.

Support by the ship and helicopter crews and by other science team members was excellent--and necessary, for there were a number of times during deployment and recovery when the one scientist assigned to our project was not enough to do the job. All preliminary indications are that the data acquisition system worked properly: for example, low frequency waves and a helicopter landing on the floes could both be seen in the digitized data

without any analytical filtering. The data system is currently in transit back to Seattle. Once it arrives and the data is uploaded to a mainframe computer, Fourier filters should isolate bumps from wave action. Extraneous radio communications did occasionally creep into the telemetry system, despite our precautions of mounting two alternative receiving antennas and building an optional notch filter. These RF signals will have to be screened out of the data file, as will the floe bumps which were caused by humans.

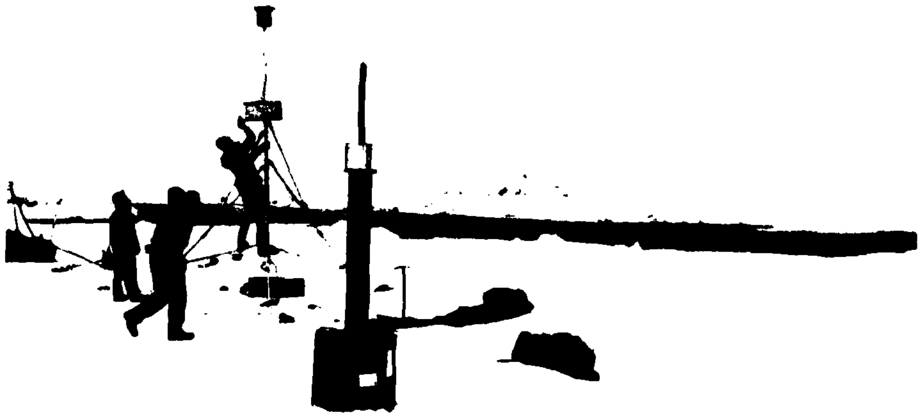


Figure 1. Installation of instruments on an ice floe. The accelerometer buoy is in the foreground; the CRREL Del Norte positioning transponder is being set up in the background.

Sea Ice Properties

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The FS Polarstern provided a unique opportunity for the examination of ice properties in that the nature of its mission in MIZEX allowed it to cover a large area within Fram Strait and its excellent cold room and laboratory facilities were very amenable to sea ice sampling and analysis. Access to ice floes for coring was both directly from the ship and from a helicopter which served to extend the geographical range of the sampling and allowed representative ice types to be sampled. Ice cores were obtained from a geographical area that extended from 78° N to 80° 42' N and from 7° 16' E to 7° 10' W. Because the Fram Strait is the major outflow region for ice from the Arctic basin, properties measured here should provide a representative sample of the pack ice in the basin.

Ice cores were taken at 54 locations from 40 individual ice floes that ranged in size from 30 m to several kilometers in diameter. Using drills powered by a light weight gasoline engine two cores were taken through the entire thickness of ice at each site. The larger of the 2 cores, measuring 10 cm in diameter, was placed in 1 m tubes and returned to the ship for structural analysis. The second core, measuring 7.5 cm in diameter, was used for ice temperature and salinity measurements. Salinity samples were prepared by cutting the core into 10 cm long segments and placing them in sealed containers at the drill site. These containers were returned to the ship where the samples were melted for salinity analysis. Many of these samples were subsequently used for chemical and biological investigations by other scientists aboard the Polarstern.

The processing of the structural analysis cores began with documentation of significant stratigraphic features. The locations of banded layers, sediment or algae layers, bubbles, and the relative degree of translucence were among the features noted for each core. After the stratigraphic examination, a vertical section about 0.5 cm thick was cut from the entire length of the core with a bandsaw. This section was examined between crossed polaroids to determine the overall nature of the crystal structure. The structure was described in terms of crystal type (columnar or granular), grain size, degree of preferred orientation, and transition zones. This examination also determined from where in each core vertical and horizontal thin sections were to be prepared.

Thin sections were prepared by first sawing a 0.5 cm thick section from the core and freezing it to a glass slide. The section was further thinned to about 1 mm using the saw and finally sliced to between 0.2 and 0.5 mm on a microtome. A cursory examination of the thin sections was conducted to roughly determine the c-axis orientations and the degree of horizontal alignment of crystals in the columnar ice. About 300 thin sections were prepared and photographs of half of these sections were made aboard Polarstern. Upon the Polarstern's arrival in Bremerhaven the thin sections will be shipped to CRREL for detailed crystallographic analysis.

Our observations indicate that most of the ice in the area traversed by the Polarstern was multi-year and that much of the first-year ice is deformed prior to entering the Fram Strait as evidenced by the many ridges and rubble piles of first-year ice located along the edges of multi-year floes. Of the 40 individual ice floes sampled, 27 were multi-year, 9 were first-year and 4 were composites, consisting of multi-year floes either embedded in first-year ice or to which remnants of first-year sea ice were still attached. As we attemped to sample first-year ice whenever possible, our sampling percentage of first-year ice is higher than that percentage actually existing in the region. The thickness of the multi-year ice sampled ranged from 174 to 574 cm. Thicknesses greater than 350 cm were usually associated with old pressure ridges. First-year thicknesses varied from 38 cm in a refrozen lead to a maximum floe thickness of 236 cm.

The mean salinity of the first-year ice floes was 4.0 $^{o}/oo$. For multi-year ice the average salinity was 2.1 $^{o}/oo$. The first-year ice showed a decrease in average salinity of about 1.0 $^{o}/oo$ as the melt period progressed from mid-June to mid-July. Over the same period the mean salinity of the multi-year ice increased about 0.3 $^{o}/oo$. Both types of ice showed a very slight salinity increase with increasing thickness. Low salinities and a crystal texture indicative of fresh ice were observed in the upper 10 cm of several first-year floes implying that melting and refreezing of the surface snow layer had occurred at some time prior to coring. In contrast, several multi-year floes had high salinities in the upper layers, most likely caused by seawater infiltration.

Deep snow on the multi-year ice masked many ablation features making it difficult to visually distinguish between multi-year and first-year ice. Snow depths on the multi-year ice ranged from 3 to 65 cm and averaged 28.5 cm. In contrast, snow cover on level first-year ice never exceeded 20 cm and averaged only 8 cm. Average snow layer thicknesses on the multi-year ice decreased from about 40 to 20 cm over the duration of the cruise. Some decrease is apparent but is much less obvious on the first-year ice. Generally, first and multi-year ice floes could be distinguished on the basis of snow depth, and from salinity and hardness (as noted by drilling or sawing) of the upper meter.

The crystal texture analysis indicates predominately congelation or columnar ice structure in both multi-year and first-year ice. Only in 11 floes did granular ice comprise more than 30% of the core thickness. This finding is in contrast with observations from the Weddell Sea region of Antarctica where more than 60% of the pack ice sampled was granular and composed principally of frazil. Where we observed granular ice in the Fram Strait, it was generally associated with ridges, occurring in refrozen voids and on the bottoms of the ridges. For the columnar ice a variety of c-axis orientations was observed. In some multi-year floes, strong horizontal alignments were noted with pronounced changes in alignment direction occurring between successive layers. At the other extreme, virtually random horizontal alignments were also noted. These orientation differences probably reflect changes in current direction relative to growth of columnar ice on the bottoms of stationary and/or rotating ice floes.

METEOROLOGY

Arctic Stratus Cloud Programme

Peter Wendling
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Within this programme measurements related to the structure and formation (dissipation) of arctic stratus clouds have been performed with the meteorological research aircraft "Falcon". The aircraft is equipped with highly sensitive instruments to measure pressure, air flow angle, temperature and humidity, thus providing a high resolution representation of the turbulent state of the atmosphere. In addition, Eppley pyranometers and pyrgeometers have been installed to measure upward and downward radiative fluxes. A downward looking PRT-6 radiometer and a radio-altimeter monitor the thermal properties and the roughness of the partly ice covered ocean surface. The instrumentation has been futher extended by the use of cloud physics probes (PMS-Knollenberg: FSSP and OAP-230X, KING-LWC-probe) and of an aerosol/cloud water sampling device which was developed and operated by the University of Stockholm. The on-board data registration provides a 10 Hz recording of all navigational (INS) and meteorological data and an additional 100 Hz recording of the highly variable temperature, pressure, humidity and flow angle sensors and radio-altimeter outputs.
Data have been collected on seven flights with a total flight time of 17 hours and 46 minutes and with a time on target of 8 hours and 21 minutes. Dependent on the structure of the low level clouds between 7 to flight legs of about 34 mm length were flown in different levels and directions.
The main research emphasis of our experiment is to understand the basic processes that lead to the formation and dissipation of arctic stratus clouds. Therefore, from the observations the following physical parameters will be determined:

- turbulent fluxes of momentum, sensible and latent heat as function of height in the PBL as well as their mean values

- microphysical cloud properties such as drop size distribution and liquid water content

- radiative cloud properties (reflectivity, transmissivity and absorptivity)

- physico-chemical and optical properties of the atmospheric aerosol.

The aircraft operation from Svalbard (Longyearbyen) has been very successful due to the excellent support by the people from the airport and from the MIZEX-Operation-Center at Tromsö. The airport is favoured by the orographic situation even in bad weather conditions. Therefore, only one flight had to be canceled due to lack of visibility (fog). In view of these advantages Longyearbyen seems to be well suited for future experiments in the Arctic. The attached table gives information on the performed flights and their location.

DFVLR Flt.No.	Date	Time	Time over target	Corner Coordinates	Remarks
1072	25.6.84	11:01-13:47	11:33-12:41	80:04N 05:20E, 80:51N 03:33E 80:07N 06:04E, 80:53N 04:20E	7 flight legs of 17 or 34 nm length in different heights between 300 ft and 13500 ft
1073	26.6.84	15:11-17:38	15:52-16:53	79:46N 00:30E, 80:33N 02:14E 80:34N 01:57E, 79:47N 00:14E	9 flight legs of 17 or 34 nm length in different heights between 300 ft and 1850 ft
1077	01.7.84	10:40-13:29	11:32-12:46	78:37N 05:30E, 78:31N 07:58E 78:07N 05:04E, 78:02N 07:27E	8 flight legs of 27nm length in a rectangular box in levels between 300 a. 1700ft
1079	03.7.84	09:04-11:32	09:44-10:49	80:00N 01:00E, 80:30N 01:00E 80:30N 01:11E, 80:00N 01:10E 79:58N 06:04E	10 flight legs of 17 or 34nm length in levels between 300 and 1700 ft
1085	10.7.84	15:03-17:25	15:42-16:41	79:00N 02:00E, 79:48N 03:36E 79:48N 03:20E, 79:01N 01:45E 79:32N 04:49E	9 flight legs of 17 or 34 nm length in different levels between 300 and 1000 ft
1086	11.7.84	08:28-11:20	09:13-10:20	79:00N 00:00E, 79:42N 00:00E 79:42N 00:17E, 79:00N 00:16E 79:21N 01:54W	10 flight legs of 17 or 34nm length in levels between 300 and 1700 ft
1089	15.7.84	08:07-09:51		south-west coast of Spitzbergen	break down of the INS sampling of aerosols in the height of 12000 ft

FALCON 20 BOUNDARY LAYER FLIGHTS

Marianne Gube and Ernst Augstein

The meteorological research aircraft Falcon 20 of the DFVLR (Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt) took part in the MIZEX field phase from 20 June 1984 to 17 July 1984. The "Falcon" operated from the airport of Longyearbyen, Svalbard. Because of the aircraft's endurance of 3 hours (with a fuel reserve for one additional hour) the average time in the measurement area was 85 minutes. A total of 20 flights, 13 for the atmospheric boundary layer and 7 for stratus cloud studies have been performed. The flight time in the measurement area for boundary layer work was 18:25 hours.

The aircraft was equipped with the following sensors: A Rosemount 5-hole sonde at the front end of the 1.8 m long noseboom for the wind vector components. Pt-100 and Pt-500 thermometers for air temperature, a Lyman α hygrometer and a Vaisala-humicap for absolute and relative humidity, respectively, and four pyrradiometers for the radiation flux components. A downward facing PRT-6 radiometer and a radio-altimeter monitored the surface temperature and roughness of the partly ice-covered ocean. Video and photographic recording through the aircraft's bottom window provided additional information on ice conditions along the flight tracks. Flight data were obtained by an Inertial Navigation System (INS), giving present position and velocity, heading, actual track angle, aircraft roll and pitch and vertical acceleration. The latter data are of special importance for the final evaluation of the true wind vector from the 5-hole sonde. The on-board data acquisition system recorded all data in a 10 Hz resolution, and additionally temperature, pressure, humidity, flow angle and radio-altimeter outputs with a 100 Hz resolution.

The aim of the boundary layer flights was to measure the turbulent fluxes of heat, water vapour and momentum under various conditions of sea ice coverage, ice floe size distribution and large scale air flow. The flight patterns consisted of a series of flight legs, each 30 nm long, with orientation parallel to the ice edge. Between 4 and 7 individual legs were flown during one mission covering an area of approximately 30 x 50 nm^2. The measurements were performed at a level of 300 ft. In 3 cases the flight pattern was repeated at second level just below the temperature inversion at the top of the atmospheric mixed layer. Cruising speed throughout the time over target was 200 knots.

During the two minidrift periods the flight patterns were centered over "Polarstern", two missions covered the meteorological buoy triangle (27 and 29 June 1984), and from 9 to 14 July the meteorological ship array was chosen as target area. The "Falcon" measurements can thus be well related to the surface and radiosonde observations performed from the ships.

A data quick-look during the flights and on ground suggests satisfactory functioning of all meteorological sensors during each flight.

<u>Table of boundary layer flight missions</u>

DFVLR Flt.No.	Date	Time over target	Corner Coordinates
1070	23.6.84	11:40-13.35	80°17'N 01°29'E, 80°29'N 04°03'E
			79°48'N 02°42'E, 80°00'N 05°17'E
1071	24.6.84	11:35-13:25	80°22'N 00°40'W, 80°34'N 01°54'E
			79°53'N 00°35'E, 80°05'N 03°10'E
1074	27.6.84	11:35-13:05	80°14'N 00°50'E, 80°33'N 04°00'E
			79°53'N 03°20'E, 79°35'N 05°40'E
1075	29.6.84	14:50-16:12	80°45'N 02°30'E, 80°25'N 04°40'E
			80°22'N 00°30'E, 80°03'N 02°39'E
1076	30.6.84	14:30-15:33	82°30'N 05°00'E, 82°36'N 08°50'E
			80°00'N 08°00'E, - -
1078	02.7.84	12:30-14:10	80°18'N 00°32'E, 80°42'N 02°22'E
			80°02'N 02°39'E, 80°25'N 04°30'E
1080	04.7.84	17:35-19:16	80°30'N 00°43'W, 80°39'N 01°42'E
			79°51'N 00°56'E, 79°57'N 02°20'E
1081	07.7.84	13:30-14:55	78°52'N 06°17'W, 79°13'N 04°39'W
			78°09'N 02°47'W, 78°30'N 01°00'W
1082	09.7.84	10:40-12:10	79°22'N 03°55'W, 79°50'N 03°10'W
			79°00'N 02°00'E, 79°28'N 03°00'E
1083	09.7.84	16:35-18:00	as flight 1082, only in height 900'
1084	10.7.84	09:40-11:50	79°22'N 03°55'W, 79°50'N 03°1[illegible]'W
			79°00'N 02°00'E, 79°28'N 03°[illegible]'W
1087	13.7.84	16:38-17:55	79°24'N 03°51'W, 79°49'N 02°[illegible]'W
			79°04'N 01°11'E, 79°31'N [illegible]
1088	14.7.84	09:50-11:20	79°51'N 00°34'E, 79°59'N [illegible]
			78°55'N 02°30'E, 79°0[illegible]'N [illegible]

AD-A148 986 MIZEX (MARGINAL ICE ZONE PROGRAM): A PROGRAM FOR MESOSCALE AIR-ICE-OCEAN..(U) COLD REGIONS RESEARCH AND ENGINEERING LAB HANOVER NH O M JOHANNESSEN ET AL. 2/2

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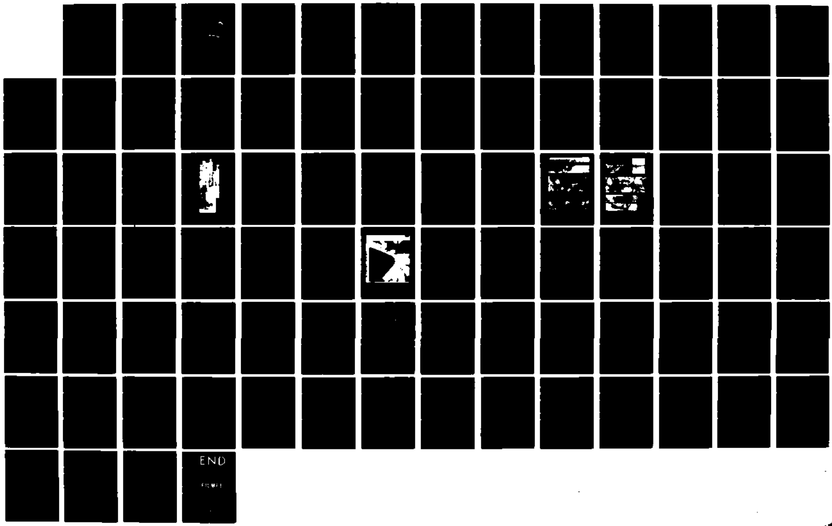

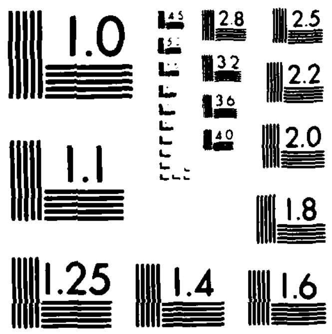

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Meteorological Investigations on FS "Polarstern"

C. Wamser

Meteorological measurements on board of FS "Polarstern" were concerned with

- the surface layer,
- the Ekman layer and
- the troposphere

Three measuring systems were installed on the ship. The turbulent momentum and heat fluxes across the air- ice- interface were measured by an ultrasonic anemometer-thermometer (Kaiyo Denki) at the boom of the bow crane at a height of 16 m above the sea surface. The data were gathered during oceanographic stations over open water and over sea ice with a sampling rate of 16 sec^{-1}. Determination of the fluxes will be performed by the aid of the dissipation method.

The vertical wind profiles and the turbulence structure in the lower 300 m of the atmosphere were investigated with a three-component monostatic Doppler- SODAR. Profiles of the reflectivity, the three wind components and the standard deviation of the vertical wind component were continuously measured during most of the stations. Due to its high time and space resolution the Doppler- SODAR has qualified for monitoring the low level wind and turbulence fields and inversion heights. Figure 1 is an example of a subsiding inversion on 10 July, 1984, showing isolines of the mean reflectivity (arbitrary units), together with 5 temperature profiles. The wind field for this case is characterized by relatively low wind velocities of about 3 m/s at the beginning which increased gradually to about 8 m/s at the end of this period. Figure 2 shows two examples of mean wind profiles at 0300 and 1330 GMT measured by the Doppler-SODAR.

The vertical profiles of temperature, relative humidity and wind velocity in the troposphere were measured with the aid of a Vaisala Micro Cora system. The determination of the wind velocity and direction is based on the OMEGA navigation technique which provided satisfactory signal quality in the MIZEX area. The launching intervall was three hours. During the cruise 249 radiosonde profiles normally up to a height of 10 km were measured. Between 19 June and 16 July, 1984, a complete data set of three hourly aerological soundings has been obtained.

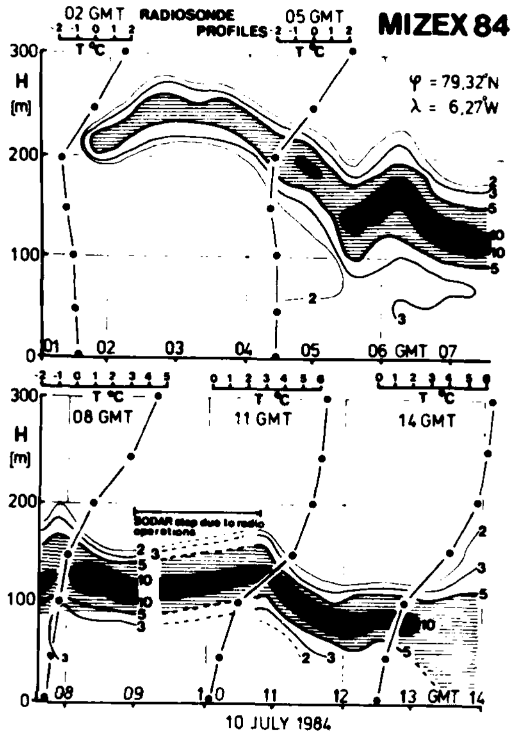

Figure 1:

Cross- section of SODAR measured reflectivity (arbitrary units) together with 5 temperature profiles during a subsiding inversion.

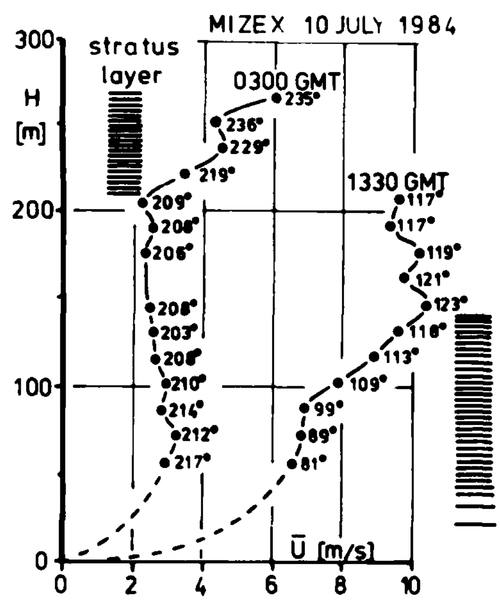

Figure 2:

Doppler-SODAR wind speed profiles. Numbers indicate wind directions, dashed fields show regions with stratiform clouds (fog).

RADIOSONDE AND SYNOPTIC PROGRAMS ON THE POLARQUEEN

R.W.Lindsay

Radiosondes were launched every 12 hours from the *Polar Queen* beginning 8 June and ending 16 July. In addition there were 3 hourly launches during the met intensive on 9 to 13 July. A total of 120 soundings were made this year. The Vaisala Micro Cora Upper Air Sounding System was used with Navaid capability to determine winds aloft. Virtually all of the soundings were tracked to 200 mb (11-12 kilometers) and included the entire troposphere which varied in height from 500 to 230 mb. The results of the 12 hourly soundings were transmitted to Svalbard Radio and were subsequently sent to the Norwegian Meteorological Institute in Tromso. There were notable differences in the boundary layer structure between the 1983 and 1984 experiments. This year the winds were in general a little stronger, there was less fog, a mixed layer was more frequently present, and surface based inversions were both less frequent and less intense.

The synoptic program was conducted in cooperation with the Naval Postgraduate School and consisted of a full synoptic ships weather observation every 6 hours which was transmitted to Svalbard Radio; and 10 minute averages of wind speed; wind direction; air temperature; dew point temperature; air pressure; and long, short and total downward radiation recorded on magnetic tape.

R/V HAKON MOSBY METEOROLOGICAL MEASUREMENTS/CONDITION

K. L. Davidson and G. L. Geernaert

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Meteorological measurements/observations on the R/V Hakon Mosby are listed in Table 1, and were near continuous from 15 June to 15 July. The principal purposes of these measurements were to provide estimates of atmospheric forcing of the upper ocean in the open ocean region of the MIZEX array and to provide pressure and radiosonde measurements at a seaward location for spatial descriptions of the MIZ synoptic and mesoscale atmospheric features.

Most sensors in Table 1 were installed and operated by Naval Postgraduate School (NPS) personnel. The wind, temperature, humidity and aerosol distributions were measured at 14 m on the forward mast. Sea surface temperature measurements were made with a floating termistor belonging to the University of Bergen Geophysical Institute. Radiation measurements were made at mid ship and from a bow boom with radiometer systems belonging to the University of Washington Atmospheric Sciences Department (K. Katsaros). The University of Bergen Geophysical Institute also installed an Anderra automatic meteorological system which provided wind (speed, direction), temperature, and humidity data, which were input to the NPS data acquisition system whenever failures occurred with NPS sensors.

Intercomparisons of meteorological values were made with the R/V Polarstern (twice), the USNS Lynch (once), the R/V Kvitbjorn (twice), and the R/V Valdivia (once). An overflight by a meteorologically equipped aircraft was made by the NOAA P-3. No other overflights in the region of the R/V Hakon Mosby by meteorologically equipped aircraft are known at this time.

Several synoptic scale systems influenced the East Greenland Sea MIZ from mid-June to mid-July and data from the R/V Hakon Mosby should characterize these quite distinctly. We observed six separate high wind (>12 m/s) periods which were associated with cyclones in the Svalbard region. Five of these cyclones were centered east and southeast of Svalbard resulting in north to northeast winds (parallel to the ice edge) over the open water region. The sixth cyclone was west of Svalbard resulting in south to southeast winds (onto the ice edge) over the open water region. The occurrence of sustained off ice wind (west to northwest) was very limited. Wind during the intensive meteorological period (9-15 July) was determined by an anticyclone east of Svalbard and was 5 to 10 m/s from the south and southwest (parallel to the ice edge). Fog, light drizzle or snow occurred on 30 to 40% of the days. Air temperatures near the ice edge caused icing on most instruments during times of fog or precipitation.

Collection of surface layer mean and turbulence data benefited from the synoptic and mesoscale CTD station procedures in which the ship was oriented into the wind and uninterrupted data were obtained for 30 to 60 minute periods. The transect patterns enabled measurements along tracts with various orientations to the ice edge and oceanic fronts. Data collected immediately adjacent to the ice edge was often adversely affected by icing of turbulent wind sensors when fog was present which was 25-35% of the time.

Dissipation estimates of the surface stress were made from both the hot film and minature cup measurements. The dissipation stress values were compared to bulk formulations of the water drag coefficient based on wind speed, e.g. Large and Pond. Evidence of secondary circulations extending into the surface layer were often observed in time series of the turbulence intensities. An interesting observed feature was the change of turbulence intensities across regions of sea surface temperature fronts.

Measurements of downward long and shortwave radiation were performed continuously. Upward reflected shortwave was measured when the sea state allowed deployment of a bow-mounted boom and the sun was visible. The general stratus/fog conditions limited the reflected shortwave data collection. Another influence on the reflected shortwave data was the bow induced wake; data could only be collected when the ship was stationary, e.g. during times on CTD stations.

Three aerosol probes were deployed to measure aerosol and droplet size distributions from .2 to 150 micron radius. The probe for measuring the fog/cloud droplets (5 to 150 μm radius) failed at the beginning. The probe for measuring the smaller sizes (.2 to 3 μm radius) operated satisfactorily during the first third of the experiment only. The probe for measuring the sea salt and haze size particles (.8 to 15 μm radius) provided data throughout the whole period.

Atmospheric boundary layer measurements from radiosondes and an acoustic sounder (SODAR) appear to have been successful from the standpoint of both system performance and the variety of conditions which occurred. Radiosondes, with Navaid capabilities for wind vector profiles, were launched according to the operational schedule: 4/day except in the intensive period (9-15 July) when 8/day occurred. A total of 136 successful launches were made. The shipboard SODAR yielded signals associated with inversion layers and convective activity up to 600 m. The system performed best on CTD stations when the ship was oriented into the wind because the ship's superstructure reduced noise caused by the wind flow over the acoustic enclosure. An interesting observed feature was the abrupt change of inversion layer height and convective activity with respect to the oceanic fronts and wind direction changes. SODAR data during the intensive meteorology period were quite good with a distinct set of inversion heights observed to be between 400-600 meters.

TABLE 1

Meteorological Measurements/Observation on R/V Hakon Mosby

Measurements	Sensor/System	Frequency
Radiation (down and reflected)	Long/short wave radiometers	Continuous
Sea Surface Temperature	Floating thermister	Continuous
Mean surface layer:		
Wind (speed, direction)	Cup anemometer, vane	Continuous
Temperature	Resistance thermometer	Continuous
Humidity	Dew cell (cool mirror)	Continuous
Aerosols	Optical Counters (.3 to 300)	Continuous
Turbulent Kinetic Energy Dissipation Rate	Hot film/ Miniature	Continuous
Inversion Height	Sodar	Continuous
Temperature, Humidity, and Wind Profiles	Vaisala (MIZEX-84 schedule)	Continuous
	Radiosonde	4 or 8/day
Sky and Sea Conditions	Visual observations	Hourly

WHITECAP OBSERVATIONS AND ASSOCIATED MEASUREMENTS DURING MIZEX 84

Edward C. Monahan

During MIZEX 84 we carried out whitecap observations aboard the HAAKON MOSBY, while aboard the same vessel the NPS, Monterey, group took detailed aerosol measurements, recorded a complete suite of meteorological variables, and used an acoustic sounder and radiosondes to characterise the structure of the MABL. On this ship P. Bowyer of U.C.G. measured the aerosol-related electrostatic space charge concentration. In this manner the essential data needed to test recent models of the aerosol budget of the MABL (those incorporating an explicit aerosol production-via-whitecaps term and an inversion sink term) were collected.

A small stainless-steel instrument shelter, equipped with window and heater, was mounted above the starboard wing of the bridge, thus providing a suitably elevated site for the U.C.G. video- and film cameras dedicated to recording large areas of the sea surface. These films and tapes will be used, as in the past, to determine the fraction of the sea surface covered by foam patches, W. W, which has long been known to depend on wind speed (U) and on the stability of the lower atmosphere (associated with the air-water temperature difference), appears, from the initial analyses of the MIZEX 83 films and tapes, to be also markedly affected by variations in sea surface temperature. It is hypothesised that this is a consequence of the fact that the whitecap bubble spectrum alters with changes in water temperature, and the decay time of individual whitecaps alters with changes in bubble spectrum.

A second, portable (shoulder-mounted), video camera was used from deck level to record the decay of individual foam patches, bubble production via ice floe-wave interaction (a candidate mechanism for significant bubble, and hence aerosol, generation in the MIZ), and windrows.

By 27 June, the date the P.I. transferred to the KVITBJORN, 44 film observations, and 88 video observations, for the purpose of determining W had been recorded. A further 7 tape segments had been devoted to recording the decay of individual whitecaps, bubble production around ice floes, and windrows. The distribution of these observations with wind speed is shown in the histogram of Figure 1.

P. Bowyer, using an Obolenski filter and a foot pump above the bridge, measured the concentration of space charge on more than 130 occasions, and subsequent to 27 June obtained several dozen additional film records of the sea surface for W-determination. Setting aside the complications caused by fog, fetch limitation, etc., a correlation is apparent between

wind speed (U), the number of jet-drop aerosols, and the concentration of space charge.

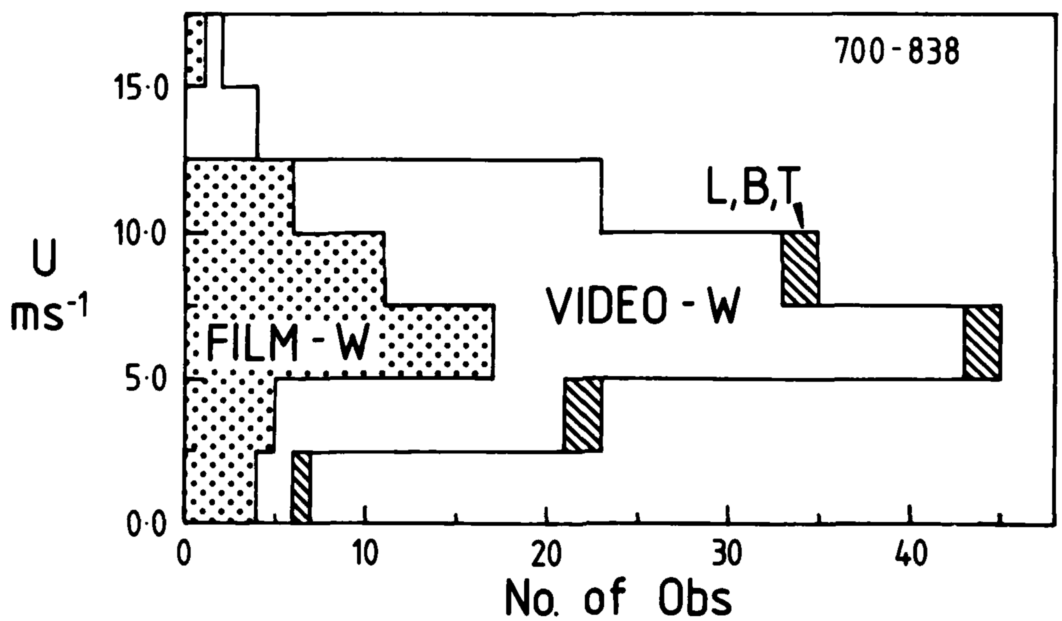

Figure 1.

R/V Polar Queen Atmospheric Boundary Layer Measurements

P. S. Guest and K. L. Davidson

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This report summarizes the surface meteorology program on the R/V Polar Queen during MIZEX-84. Sensors were mounted on a bow mast and on adjacent ice floes while the ship was moored and drifting with the ice. Signal and power to the ice instruments were by cables from a shipboard laboratory. The various sensors and measurements are listed in Table 1. The surface meteorology instruments were installed and maintained by Naval Postgraduate School personnel. All instruments worked successfully during the experiment and data that are being processed will be used to understand air/sea/ice processes on synoptic, meso, and micro scales.

An objective of this measurement program was to understand and to quantify the vertical momentum and heat fluxes in the surface layer. The measurements for estimating surface fluxes included profile measurements of wind and temperature and fluctuation measurements of wind and temperature and fluctuation measurements (Hot film) of the wind on the bow mast of the Polar Queen. Another objective was to characterize the depth, turbulent intensities and wind profiles in the boundary layer extending to heights of 500 meters. This was accomplished with the doppler acoustic sounder (SODAR). A final objective was to obtain data to correlate with the radiation measurements. This was accomplished with measurements of the fog droplets using a optical spectrometer which yielded droplet size distributions from 10 to 300 Mm diameter.

The typical weather conditions during the experiment were 4-7 m/s winds with low stratus clouds. During June, there were several snow showers and the ice surface was covered with snow. During the period winds were generally northerly and fog was rare. Later, in July, there was more fog and drizzle, and less snow, so that the snow was almost entirely melted from the ice surface. There were three events of winds greater than 10 m/s with a maximum of 13 m/s. During these events, wind directions were favorable for all flux measurement sensors. The temperature ranged from -5 to 4C and the atmospheric stability was usually near neutral. We believe atmospheric forcing was accurately observed during times when the Polar Queen was drifting significantly.

The measurements which provide information on surface fluxes of momentum received the most attention during the experiment and in our preliminary analyses. The wind profile on the ice mast revealed that wind speeds from 0.75 m to 6.0 m had excellent fits to typical log-linear profiles. Interestingly, wind profiles showed no evidence of internal boundary layers at locations 20 m from the edge of 700 m diameter floes. Fluxes derived from the profile measurements will be compared with sonic anemometer and hot film measurements taken simultaneously.

Preliminary analysis of the hot film measurements from the ice mast show good agreement with the profile method. The ice mast 10 meter drag coefficients, C_D, from both profile and hot film ranged from 1.2×10^{-3} to

2.5×10^{-3}. These are a measure of the skin friction drag due to the ice floe surface, but do not include the form drag due to ridges and floe edges.

The hot film data from the bow mast, located 18 meters above the surface, yielded drag coefficients of 1.8×10^{-3} to 4.0×10^{-3}. We believe these higher values are representative of a larger surface area and include form drag effects. The ice mast temperature profiles have yet to be examined but we believe they will yield results on the largely unknown temperature bulk exchange coefficient over ice surfaces.

The Doppler Acoustic Sounder (Doppler SODAR) was deployed on the ice surface away from the ship to avoid noise interference. The entire system functioned well unless winds were greater than 9 m/s when pressure fluctuation induced noise affected the signal. This system is designed to yield wind profiles up to 500 meters as well as information on turbulent intensities. Our interest is to correlate this information with both the surface layer measurements and the radiosonde data obtained by R. Lindsay of the University of Washington. It is believed that reasonable data were obtained from the doppler SODAR during the last 5 weeks of the experiment.

TABLE 1

Atmospheric Boundary Layer Measurements/Observation on R/V Polar Queen

Sensor	Parameters Measured	Locations [1]
Cup anemometer	Average wind speed	Bow mast Ice mast Ice tower (4)
Wind vane	Average wind direction	Bow mast
Radiation shielded and aspirated platinum wire thermometer	Average temperature	Bow mast Ice tower (4)
Condensation Dewpoint/Frostpoint hygrometer	Average humidity	Bow mast
Hot film anemometer	Turbulent Kinetic Energy Dissipation, Momentum flux	Bow mast Ice mast
Sonic anemometer with thin platinum wire thermometer	3-d wind and temperature, fluxes, spectral properties	Ice mast
Radiometer	Long, short and total downward radiation	Ship deck
Doppler Acoustic Sounder	Wind velocity profiles, Inversion levels, Turbulence structure parameters	Ice surface
Barometer	Atmospheric surface pressure	Ship Lab
Optical Array Probe	Coarse suspended particulate matter	Ship deck
Hourly Observations	Sky conditions, visibility, sea or ice conditions, precipitation	Ship bridge

[1] Bow mast -- Instruments are mounted on a boom extending forward 3 meters from the forward mast at a height of 18 m.
Ice mast -- 2.8 m tower with cross bar for instruments
Ice tower -- 6 m tower with 4 wind speed and temperature levels.

METEOROLOGICAL ICE FLOE STATIONS OF HAMBURG UNIVERSITY

H.C.Hoeber

Meteorological Institute, Hamburg

Three automatic meteorological surface stations (H1, H2, H3 according to the MIZEX operations plan) were deployed on ice floes on 19, 21 and 23 June 1984, respectively. Their position was monitored through the ARGOS system; the position data set is included in the common data tape of all ARGOS platforms (ID code: 5430, 5431, 5432).

Due to electronic malfunctioning which is believed to be caused by electrostatic charging and discharging during the helicopter transport only stations H1 and H2 delivered data comprising five minute averages of surface pressure, temperature, wind speed and direction. The stations formed a triangle of 80 to 200 km sidelength of which H1 and H2 moved southward rather fast, while H3 deployed east of POLARQUEEN remained almost stationary. The stations, therefore, were recovered on 1, 2 and 3 July 1984, respectively. A redeployment was scheduled but turned out to be impossible after the necessary helicopter experienced a damage beyond repair thus terminating this programme.

With the exception of wind speed at station H1, the data - on first inspection - appears to be of reasonable quality. Small scale ice drift evaluation, however, will be hampered due to the loss of the NOAA 8 satellite which caused a position data gap each day between 5.30 and 12.30 GMT.

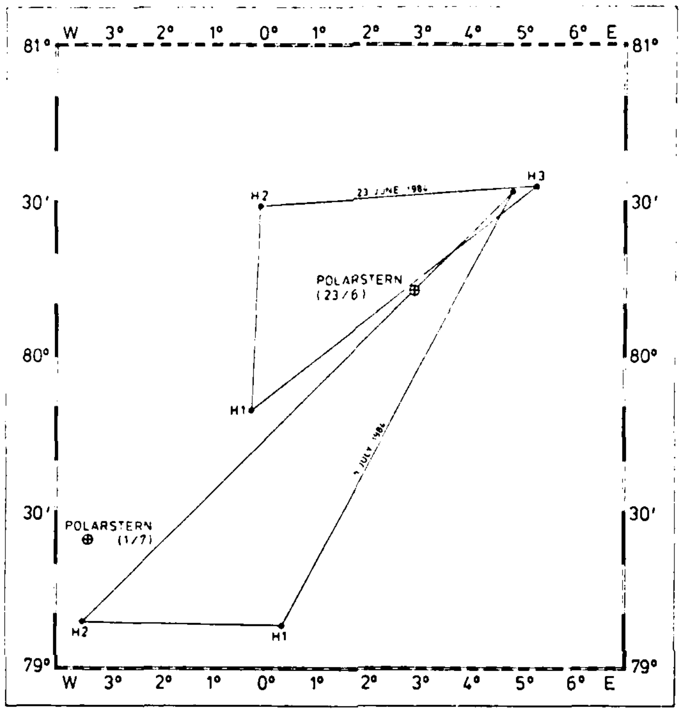


Fig. 1 - Hamburg automatic meteorological surface stations on ice floes. Positions at first and last day of complete triangle deployment are shown, in addition to position of POLARSTERN.

Wind Stress and Micrometeorology From Kvitbjorn

R.J. Anderson and S.D. Smith, (BIO), R.E. Mickle, (AES)

The principal objective of this study was to obtain values of wind stress and air drag coefficients for a variety of ice types and weather conditions characteristic of the MIZEX area. Another objective was to monitor the atmospheric boundary layer structure and maintain detailed meteorological records for the cruise.

Instrumentation: Sensors including a fast response propellor vane anemometer and microbead thermistor from BIO and cup and vane anemometer, relative humidity and air temperature from AES were mounted on a bow mast. The BIO sensors are used for measurements of wind spectra from which the wind stress can be determined by the dissipation method.

A three-axis sonic anemometer was deployed on the ice for more direct eddy-correlation measurements of wind stress when it was feasible to work on the ice. Profiles of wind, temperature and humidity through the atmospheric boundary layer were obtained with a tethersonde system winched from the ice and short and long wave radiation were monitored with radiometers mounted over the bridge. A PRT-5 and thermistor probe were used to measure sea surface temperature.

Data Recording: The bow instruments were operational from July 2-21 during which period 88 data runs of 15 to 45 minutes duration were obtained by BIO and logged in digital format on cassette tape. Qualitative observations of ice type and concentration and some photos were taken especially for sonic anemometer runs. Ice conditions varied from smooth to very rough and from continuous unbroken ice to open water. The sonic anemometer was operated during mini-drift phases only, with 30 runs obtained on July 4-7 and 15 runs on July 17-19. Comparison with the eddy correlation method will allow testing and calibration of the less direct dissipation measurements of wind stress. Hopefully we can relate the roughness from the laser profilometer line flown on July 6 to the wind stress measured by the sonic anemometer. Data from the first mini-drift period was the more productive since light winds (<5m/s) during the second period were less conductive to accurate determination of the drag coefficient. Of the total BIO data set, 28 runs had winds from 8-11 m/s and 57 runs had winds between 5-11 m/s.

Routine meteorological data were logged as 5 min. averages for the bow anemometer, air and sea temperatures, radiation, relative humidity and air pressure for July 2-23. Standard log sheets of surface meteorological observations were completed every 6 hrs. Satellite positions were logged every minute. Preliminary analysis of radiation data gives albedo as 5-7%.

The tethersonde system was deployed from the ice whenever the ship was moored to a floe. The boundary layer profiles will be used to help in the interpretation of wind spectra by the dissipation method and will also be used together with the meteorological observations from other vessels to characterize boundary layer conditions. Approximately 50 profiles to 100 m were obtained.

WEATHER OBSERVATIONS - USNS LYNCH

R. A. Helvey

Upper-air and surface weather observations were made during MIZEX-84 on board the USNS Lynch by two personnel from the Pacific Missile Test Center (PMTC), while in the Greenland Sea from 8 to 24 June, 1984. Our primary goal was to collect data for use in assessing the accuracy and representativeness of microwave index of refraction profiles derived from several different types of radiosondes, under polar maritime conditions.

Radiosondes employed were Beukers 1524 Microsondes, VIZ Research sondes, and Vaisala RS80-15 sondes. The latter two measured only pressure, temperature and humidity, but the Beukers additionally utilized Omega Navaid signals to obtain winds aloft. Termination altitudes varied from sounding to sounding, but typically at least 10 to 15 km were attained.

Because the Beukers system was not available soon enough before commencement of operations, familiarization trials and software modification to facilitate its use were carried out at sea. The first successful Beukers sounding took place on 16 June, with two to four releases per day thereafter up to the morning of 23 June. A total of 22 Beukers soundings were attempted during this period, of which about 30% experienced serious problems in acquiring or archiving data. In addition, from 13 to 21 June a total of seven joint Vaisala-VIZ ascents were made, with the two different sondes strapped together side-by-side for comparison purposes. Performance of these two sonde types was generally excellent, judging from the raw data received.

Surface observations of pressure, wind, temperature, dewpoint, sea state and sky conditions were made at intervals varying from hourly to six-hourly, depending on PMTC personnel workload and duty schedules. Bridge weather observations by the ship's crew were transcribed for two-hour intervals. One-minute average pressure, temperature and dewpoint measurements were also collected automatically and recorded digitally, although periods of data loss and calibration drift were apparent.

The radiosonde and surface digital data were recorded in essentially unreduced form on a variety of computers and media, and will require editing and other processing before transfer to nine-track magnetic tape for inclusion in the MIZEX data base.

WEATHER MAPS FROM VERVARSLINGA FOR NORD-NORGE, TROMSØ

Erik Mollo-Christensen, NASA/GSFC, Code 671, Greenbelt, MD 20771

Weather maps were photographed at the Weather Forecasting Center for Northern Norway (Vervarslinga for Nord-Norge) and Xerox copied for the times listed.

I have saved slides of small scale maps (Fram Strait) at 127 for the following Julian days:

169,170,172,173,174,175,176,177,178,179,180,181,182,183,184,185,186,187, 189,190,191,193,194,195,196,197,198.

Additionally, I have saved the slides of small scale maps for the following days and times:

172: 06 Z, 09 Z, 12 Z, 15 Z,18 Z, 21 Z,
173: 00 Z, 03 Z, 09 Z, 12 Z, 15 Z, 18 Z, 21 Z
174: 00 Z, 03 Z, 06 Z, 09 Z, 12 Z, 15 Z, 18 Z, 21 Z
175: 12 Z
176: 00 Z, 03 Z, 06 Z, 09 Z, 12 Z, 15 Z
177: 00 Z, 03 Z, 06 Z, 09 Z, 12 Z, 15 Z, 18 Z, 21 Z
178: 00 Z, 03 Z, 06 Z
179: 00 Z, 03 Z, 06 Z, 09 Z, 12 Z, 15 Z, 18 Z, 21 Z
180: 09 Z, 12 Z, 15 Z, 18 Z, 21 Z
181: 12 Z
182: 12 Z
183: 06 Z, 09 Z, 12 Z, 15 Z, 18 Z
184: 06 Z, 09 Z, 12 Z, 15 Z, 18 Z, 21 Z
185: 12 Z, 18 Z, 21 Z
186: 00 Z, 03 Z, 06 Z, 09 Z, 12 Z, 15 Z, 18 Z, 21 Z
187: 00 Z, 03 Z, 12 Z
188: 00 Z, 09 Z, 12 Z, 15 Z, 18 Z, 21 Z
189: 00 Z, 06 Z, 09 Z, 12 Z, 15 Z, 18 Z
190: 00 Z, 06 Z, 09 Z, 12 Z, 15 Z, 18 Z
191: 00 Z, 03 Z, 06 Z, 09 Z, 12 Z, 15 Z, 18 Z, 21 Z
192: 03 Z, 06 Z, 09 Z, 12 Z, 15 Z, 18 Z, 21 Z
193: 00 Z, 03 Z, 06 Z, 09 Z, 12 Z
194: 12 Z
195: 12 Z, 21 Z
196: 12 Z

The following maps are also in the form of Xerox copies, including the Fram Strait and East Greenland, with a strip of the coast of Norway showing:

169: 12 Z, 170: 12 Z 172: 12 Z, 173: 12 Z 174: 12 Z 175: 12 Z 176: 12 Z
177: 12 Z 178: 12 Z 179: 12 Z 180: 12 Z 181: 12 Z 182: 12 Z
183: 06 Z, 09 Z, 12 Z, 15 Z, 18 Z, 21 Z
184: 00 Z, 03 Z, 06 Z, 09 Z, 12 Z, 15 Z, 18 Z, 21 Z
185: 00 Z, 03 Z, 06 Z, 09 Z, 12 Z, 15 Z, 18 Z, 21 Z
186: 00 Z, 03 Z, 06 Z, 12 Z, 15 Z, 18 Z, 21 Z
187: 00 Z, 03 Z, 06 Z, 09 Z, 12 Z, 15 Z, 18 Z, 21 Z
188: 00 Z, 03 Z, 06 Z, 09 Z, 12 Z, 15 Z, 18 Z, 21 Z
189: 00 Z, 03 Z, 12 Z
190: 12 Z 191: 12 Z 192: 12 Z 193: 12 Z 194: 12 Z 195: 12 Z 196: 12 Z
197: 12 Z 198: 12 Z

Weather maps for every three hours are archived at Vervarslinga for Nord-Norge in Tromsø, I have copied the above maps for the convenience of MIZEX project participants, and because they are of direct interest in my own research. The attached figure shows a copy of a slide showing the weather map on June 24, when there was a low pressure in fram Strait during the CV-990 overflight.

Additionally, I have copies of the ship reports, for the period June 15 through July 11.

The digitized weather maps still need some glitch removal processing and will take some time.

REMOTE SENSING

ERIM/CCRS CV-580 SAR DATA COLLECTION AND ERIM SURFACE OBSERVATIONS DURING MIZEX 84

R. Shuchman, C. Livingstone, B. Burns, R. Larson

During the period 29 June-10 July, the CV-580 conducted 7 flights over the MIZEX experimental area in the Fram Strait and three additional missions over Svalbard and the Norwegian Sea. Synthetic aperture radar (SAR) imagery was collected in all missions, scatterometer data on one flight, and aerial photography as weather permitted. In addition to the aircraft activities, ERIM personnel also carried out surface truthing from the POLARSTERN, obtaining primarily dielectric constant and snow wetness measurements of the snow cover. Both aircraft and surface efforts are summarized here.

The seven CV-580 missions over the experimental area each produced mosaics of X-band (3.2 cm) and L-band (23.5 cm) SAR imagery. It had been planned that C-band (5.7 cm) imagery would also be collected, but due to breakage during shipping, the C-band SAR could not be used. Mosaics of the area (approximate) 80° to 81°N and 0° to 4°E were obtained on 29 June and 6 July, mosaics of the area 78° to 79°N and 4°W to 0° on 5, 7, and 9 July; and the area 78°30' to 80°N and 2°W to 2°E was imaged on 30 June. Three lines of dual polarization, dual frequency SAR imagery and one line of scatterometer data were obtained on the night of 9/10 July in the area of the POLARQUEEN.

Based on the real-time imagery and the optical data processed to date, the SAR imagery show very clearly the changes in floe surface conditions as the summer melt progressed and the dynamics at the ice edge. The mosaic obtained 5 July portrays the eddy structure at the edge especially well.

The objective of the surface program was to obtain measurements of the snow cover parameters critical to interpretation of remote sensing microwave data. Dielectric constant and snow wetness measurements were carried out with emphasis on coordination with scatterometer measurements made from helicopter and ship, and with aircraft SAR, SLAR, or PMI data collection.

During the period 18 June through 14 July, nineteen sites were visited where dielectric constant measurements with the 100 MHz Q-meter and the L-band coax system were taken at various depths in the snow cover. For most sites, snow samples were taken back to the ship and free water fraction measured in the cold room under controlled conditions. (Equipment for measuring the free water fraction of snow was supplied by CRREL.) At two sites, snow wetness was measured on the floe, but due to the lengthiness of the measurement and the shortness of the stations, this was not continued. Auxiliary data collected at each site included snow depth, crystal size, snow temperature, and snow density. Nine of the site measurements were coordinated with shipscat measurements made by U of Kansas, five with U of Kansas heloscat flights, two with aircraft PMI overflights, and seven with aircraft SAR or SLAR overflights.

Conditions found during this period ranged from very dry, cold snow cover with a crust to melting conditions. For these two extremes, free water

fraction (by volume) ranged from approximately 0% to 7.3%, dielectric constant (at the surface) from 1.45 to 3.2, and loss tangent from 0.007 to 0.07. Additional measurements of dielectric constant at X-band were made in the cold room on both first-year and multiyear cores obtained by the CRREL group.

In addition to surface measurements, an incident power receiver was placed on the deck above the bridge to record the antenna pattern of the aircraft SAR as it passed over. Incident power from the CV-580 SAR was recorded on both 5 July and 9 July overflights. During the 9 July overflight, an active calibration device and corner reflectors were placed on floes for both identification and calibration purposes.

REPORT ON FRENCH B-17 OPERATIONS IN MIZEX-84

W. Campbell, N. Lannelonge and D. Vaillant

During the period 28 June through 19 July 1984, the B-17 of the National Geographic Institute of France (IGN) performed five mesoscale radar mosaic mapping missions in MIZEX-84. The aircraft was equipped with the Varan S (Thomson-CSF/CST/IGN) X-band digital SLAR. The aircraft also was equipped with the same Litton inertial navigation system as that used on the Concorde, therefore very accurate navigation was possible during the complex maneuvers required during each mapping mission.

All five B-17 radar mapping missions were successful. Each took place under adverse weather conditions, and the flights were all timed so that the radar mosaic mapping occurred at approximately noon GMT on the day selected. Because the B-17 is not a fast aircraft (normal cruising speed is 140 nm/hour) and the distances were great, the duration of each flight was long; the shortest flight was eight hours and the longest was thirteen hours.

As fate would have it, the period of operation of the B-17 was also a period of strong ice and ocean dynamics in the MIZEX area. Indeed, conditions were changing so rapidly that the complex flight plan for each B-17 mission was changed after take-off. An important advantage of the slow speed of the B-17 is that some time is available during the approach to the target area in which to change plans, an option usually not possible in faster aircraft. Of course, high-quality navigation and flying is essential even in a slow aircraft, and the success of the B-17 flights was due to the extremely high-quality performance of the IGN flight crew.

After each flight a cartoon of the radar mosaic data was made as quickly as possible and transmitted to the POLARSTERN to aid in the execution of the experiment. These data proved to be very useful to the scientists in the field. During the last three flights, when the surface was completely cloud covered and much fog was present, the B-17 radar data was used in a real-time mode when data from facsimile charts were transmitted by radio to the ships. In short, every effort was made to get useful B-17 radar data to the field scientists as rapidly as possible.

The data selected for each flight were determined amid an array of variable factors - joint missions with other remote sensing aircraft, surface conditions, weather, logistical problems, etc. The flights occurred on the following days: 30 June, 6 July, 11 July, 14 July and 16 July 1984. The first flight was flown out of Tromsø with a return to Tromsø. This mode of operation proved to be excessively consumming of aircraft flight hours, so the decision was made to switch operations to Longyearbyen. Thus, the flight of 6 July originated in Tromsø and ended in Longyearbyen, the flights of 11 and 14 July originated and ended in Longyearbyen, and the flight of 16 July originated in Longyearbyen and ended in Tromsø.

The five radar mosaics obtained by the B-17 cover large sea ice and oceans areas, the average area being approximately $1.3 \times 10^4 km^2$. The shape and size of each radar mosaic varies and was determined in the trade-off between

maximum coverage and available flight time. The coordinates of the corners of each mosaic flight are:

30 June:	(1)	79°48'N,	04°40'E
	(2)	78°55'N,	04°40'E
	(3)	78°55'N,	01°00'W
	(4)	79°48'N,	01°00'W
6 July:	(1)	79°53'N,	03°15'E
	(2)	79°00'N,	03°15'E
	(3)	79°00'N,	02°00'W
	(4)	79°53'N,	02°00'W
11 July:	(1)	78°40'N,	01°00'E
	(2)	77°57'N,	02°05'W
	(3)	78°41'N,	05°40'W
	(4)	79°16'N,	02°30'W

plus two overlapping bands covering a width of $\sim$16 nm extending from the center of the NW side of this box to:

(5)	79°45'N,	06°37'W
(6)	79°34'N,	06°40'W

plus one band covering a width of $\sim$8 nm extending from (5) to (6).

14 July:	(1)	79°30'N,	00°30'W
	(2)	79°00'N,	02°30'E
	(3)	78°06'N,	01°40'W
	(4)	78°37'N,	04°30'W

16 July: same as 14 July.

The immediate task is to process this vast amount of high-quality digital SLAR data. This is a formidable task! A study recently performed at CNES (French Space Agency) Toulouse showed that to process a 20 km x 20 km area of the data on the largest computer at CNES will take six days. To process all the B-17 MIZEX-84 data would take approximately three years. Since there is no way that CNES can devote their largest computer to us for years, we must explore other means for processing. This problem will be discussed at a French MIZEX Remote Sensing meeting at CNES-Paris on 24 September 1984.

NRL RP-3A MIZEX 84 EXPERIMENT REPORT

J. P. Hollinger
Naval Research Laboratory

M. R. Keller
Bendix Field Engineering Corp.

The Naval Research Laboratory conducted airborne microwave radiometric imaging measurements at 90 GHz over the marginal ice zone in the Greenland Sea using the NRL RP-3A aircraft from 26 June to 9 July 1984. In addition, microwave radiometers at 19, 22, and 31 GHz were used to obtain profile measurements at nadir. Details of the radiometers are given in Table 1. Environmental sensors provided pressure, air temperature, dew point temperature, and liquid water content. The aircraft inertial navigation system (INS) provides wind speed and direction at the aircraft altitude as well as pitch, roll, track angle, heading, latitude, and longitude. A PRT-5 infrared thermometer was used to obtain surface temperature, a 70 mm Hasselblad motorized frame camera was used for aerial photography, and a trained ice observer participated in the flights to define ice type and coverage from the aircraft when visibility permitted. Two sets of flights were made. One set consisted of three flights at 7.56 km altitude to map a 117 by 139 km region containing the marginal ice zone at 90 GHz. The other set consisted of a flight at 1.8 km altitude to map a 52 by 123 km region of the ice pack at night, and low altitude (0.9-1.8 km) flights to obtain high resolution data at all the microwave frequencies. Emphasis was placed upon coordinating with ground truth surface teams to assure exact correspondence between surface truth measurements and the airborne microwave data.

Flight 1 was flown on 26 June 1984 at two altitudes (Figure 1). Twelve parallel tracks were flown at 7.6 km to collect the data for the first 90 GHz high altitude map. Three legs were flown at 0.9 km to obtain 19, 22, and 31 GHz profile measurements at nadir in the area of POLARQUEEN. Flight 2, flown on the night of 28 June, consisted of nine parallel tracks, which were flown at 1.8 km (Figure 2). This 90 GHz high resolution map will be used to examine the microwave properties of summer ice during night time freezing conditions. A tenth track, flown at 1.2 km, produced 90 GHz imagery from the interior of the pack through the loose ice to open water. The 90 GHz image data for the second high altitude ice map were collected during flight 3 (Figure 3), on 2 July 1984, which consisted of twelve parallel tracks at 7.6 km altitude. Two parallel tracks to and from the north pole, were flown during flight 4 on 4 July 1984 (Figure 4), to obtain 90 GHz imagery of the ice pack to the pole. During flight 5, on 6 July, 90 GHz imagery of the area around POLARQUEEN and POLARSTERN was generated. Six tracks were flown over the POLARQUEEN at various altitudes (Figure 5). Tracks 1 and 2 were flown at 7.6 km, track 3 and 4 at 3.7 km, track 5 at 1.8 km, and track 6 at 0.9 km. The last four tracks of the flight were flown at 0.9 km over POLARSTERN. The sixth and final flight was on 9 July. Twelve parallel tracks were flown at 7.6 km (Figure 6) to produce the data for the third 90 GHz high altitude map.

Excellent 90 GHz data were collected during the six flights, but were occasionally marred by radio frequency interference (RFI). This problem was especially severe throughout the first flight on 26 June, when RFI was present nearly all the time. Profile data were collected at 19, 22, and 31 GHz. The 22/31 GHz radiometer produced consistently good results on all flights. On June 26 (flight 1) and July 9 (flight 6), the 19 GHz radiometer malfunctioned,

causing it to either fail or produce inconsistent calibrations. For the majority of the rest of the flights, the 19 GHz radiometer was stable and yielded accurate data. Since the marginal ice zone was cloud-covered during most of the mission, 35 mm and 70 mm photography was only taken during breaks in the clouds. Thus, on 26 June (flight 1), 2 July (flight 3), 6 July (flight 5), and 9 July (flight 6), photographs were taken intermittently. On 28 June (flight 2), and 4 July (flight 4); however, because of clearer conditions, more continuous photographic coverage exists.

Data reduction for MIZEX '84 will commence upon the complete installation of a new computer. The high altitude ice maps and night mosaic should be reduced by spring 1985, and the ship passes and polar flights by summer 1985.

TABLE 1

NRL AIRBORNE RADIOMETERS

Center Frequency GHz	Wavelength mm	IF Frequency	System Noise,K	Sample Rate	RMS Noise per Sample	Half-Power Beamwidth
Imaging Radiometer						
90.0	3.3	0.8 to 2.2GHz & 2.9 to 5.2GHz	1,700	2.4 KHz	1.4	1.0^{0}
Profiling Radiometers						
19.3 H & V	15.5	30 to 300MHz	1,000	10 Hz	0.5	8.0
22.2 V	13.5	5 to 500 MHz	1,000	10 Hz	0.4	8.0
31.0 H	9.7	5 to 500 MHz	1,000	10 Hz	0.4	8.0

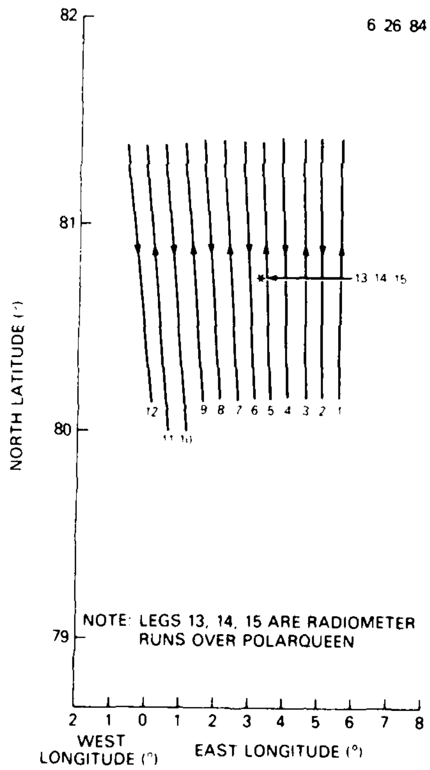


Figure 1. Flight 1 track pattern

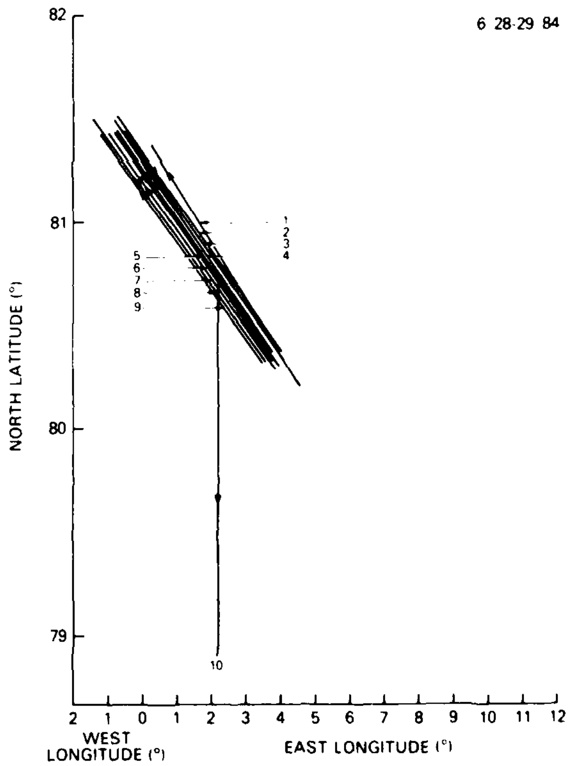


Figure 2. Flight 2 track pattern

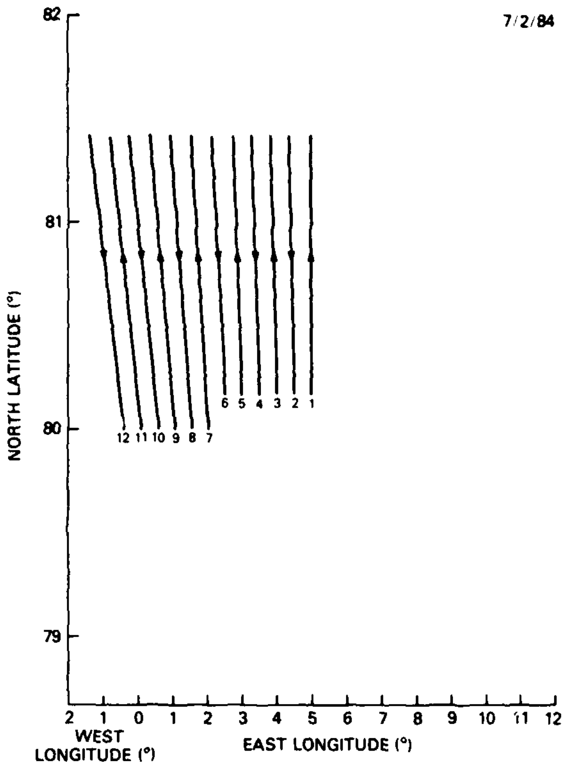


Figure 3. Flight 3 track pattern

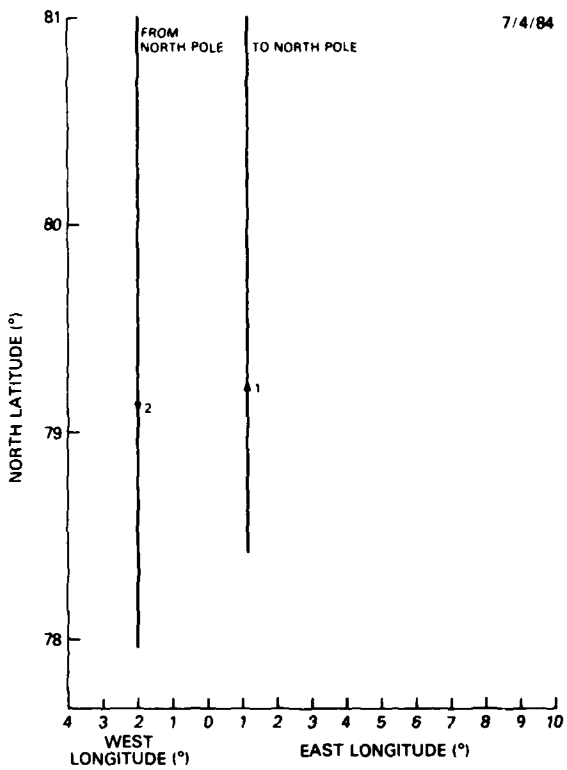


Figure 4. Flight 4 track pattern

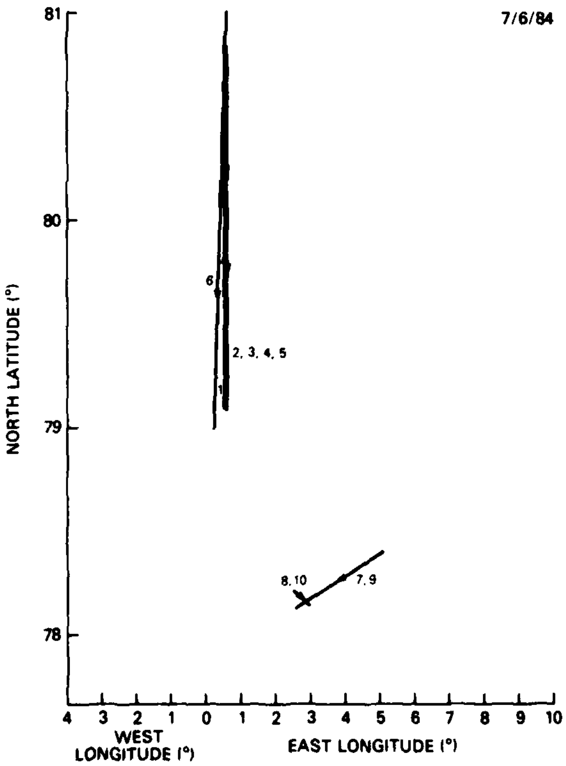


Figure 5. Flight 5 track pattern

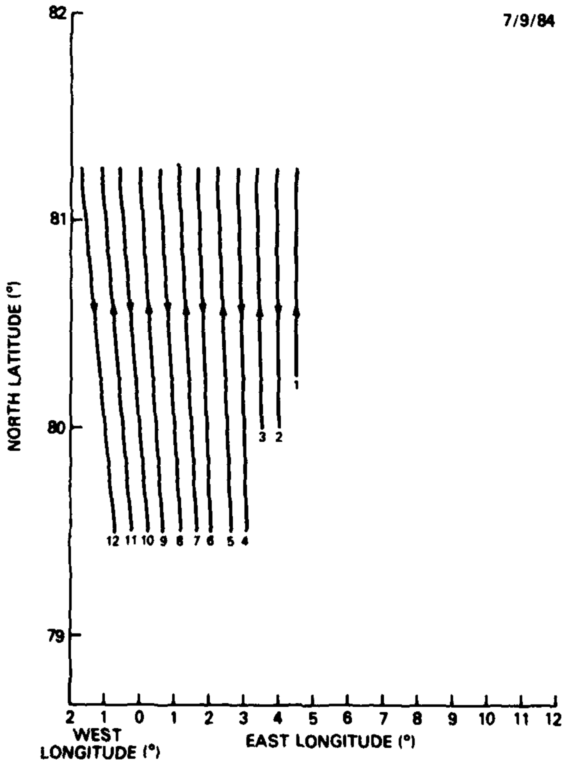


Figure 6. Flight 6 track pattern

NASA/CV-990 ACTIVITIES DURING MIZEX'84

Per Gloersen

General - Of the thirteen test, transit, and local flights made by the NASA CV-990 during this campaign, nine of them had data pertinent to MIZEX'84 and are outlined below. When mosaic patterns were flown, they were from an altitude of ca. 5 nm with legs 10 nm apart.

Day 160 - 6/8 - Ames/Thule - Transects - Some sea ice data were obtained over Hudson Bay, Foxe Basin, and part of Baffin Bay. Excellent conditions for useful albedo measurements were obtained -- both high and low level.

Day 161 - 6/9 - Thule/Evenes - Six-leg North/South Mosaic - Center near 81°N, 6° 10'E - Cloudy - Polarqueen was estimated to lie between the two center legs, about 60 km from the southern edge. The real-time airborne ESMR images indicated that the ice was near or above the melt point over the entire MIZEX area.

Day 164 - 6/12 - Evenes RT - Six-leg North/South Mosaic - Center near 81°N, 8° 10'E - Mostly cloudy - Polarqueen was directly underneath us on the westernmost leg of the mosaic pattern. The ESMR mosaic prepared on board showed that the ice was below freezing in the southern part of the MIZEX box, but at the melt point elsewhere.

Day 170 - 6/16 - Evenes RT - Long Four-leg North/South Mosaic - Center near 81° 45'N, 5°E - Partly cloudy - Freezing conditions were found in the MIZEX box and near-melt conditions further north. This was coupled with observations of scattered ice-clouds over MIZEX and heavy clouds north of there. Polarqueen was situated between the two westernmost legs. We were startled to find the sea ice extending some 110 km south of the edge as observed on the first leg; possibly we were observing part of an eddy. This information was radioed to the Polarqueen as we departed the area.

Day 174 - 6/20 - Evenes RT - Five-leg North/South Mosaic with 500' repeat of center leg - Center near 80° 36'N, 6° 20'E - Cloudy - The center legs were coincident with intensive surface meaurements and the NOAA P-3 transect. The conditions were generally warm and cloudy over all of the MIZEX box, accompanied by the radiometric signatures typical of sea ice near the melting point. In addition to providing an excellent visual evaluation of ice conditions along the low-level transect, we obtained albedo measurements of the solid pack, the ice margin, and the open sea with varying wave structure, albeit with a solid overcast. The low-level transect was extended to about 79° 30'N. The visual observations confirmed the presence of fresh snowfall over the entire area. Meltponds, although comprising less than 1% of the entire area, were observed to contain water.

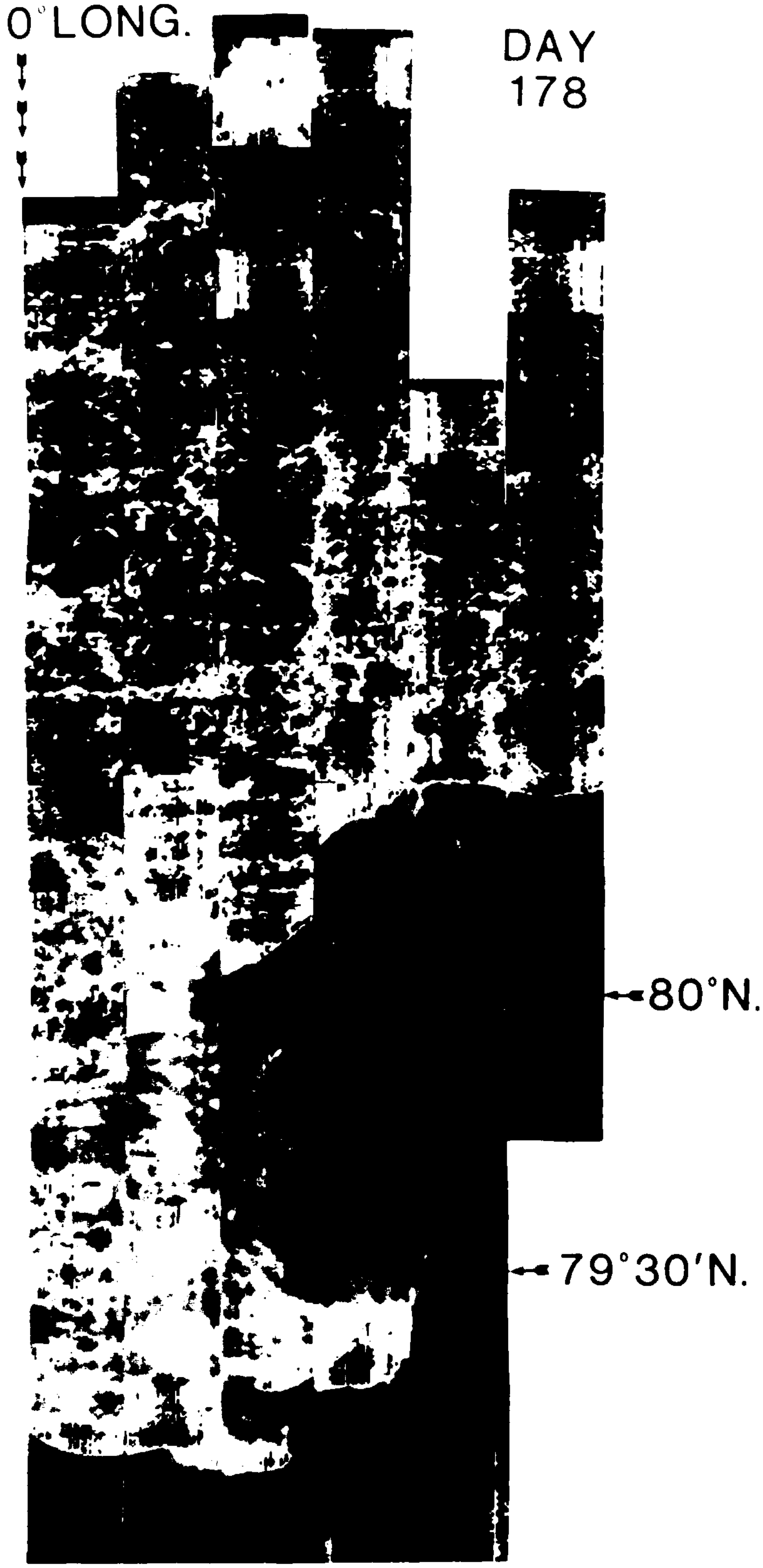
Day 176 - 6/22 - Evenes RT - Six-leg North/South Mosaic - Center near 80° 40'N, 4°E - Cloudy - Both Polarqueen and Polarstern were within the pattern. The two easternmost legs were spaced 5 nm apart so that both the radiometers and the altimeter could repeat observations of the Day 174 low-level run. About 100 km south of the east/west ice edge, an ice streamer, about 25 km in

extent, was observed to meander mostly due east and then south. The MIZEX area appeared rather compact, with relatively few open leads all less than 1 km wide in evidence. The pack signature was monotonously that of moist sea ice, so the floe structure was indistinguishable. The ice edge in the MIZEX box was quite compact, but had an astonishingly regular sine-wave pattern with a wavelength of about 28 km. About 2-1/2 oscillations were observed. A solitary thin ice band, ca. 1 km wide, was observed running east/west about 30 km south of the edge across the two easternmost legs.

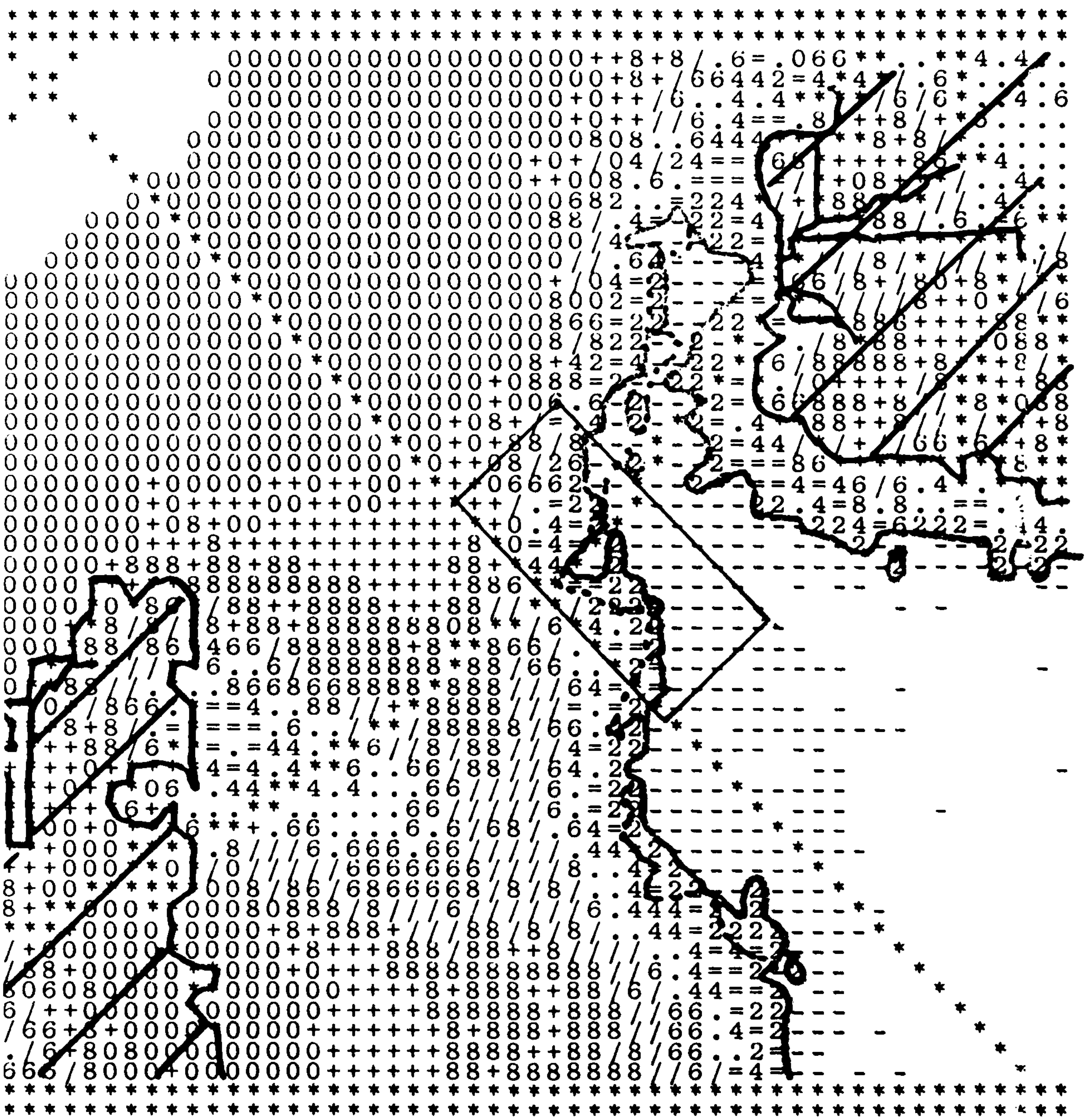
Day 178 - 6/26 - Evenes RT - Six-leg North/South Mosaic - Centered near 80° 30'N, 2° 30'E - Partly cloudy - While there were some interesting (cold) multiyear ice features to the west, this was definitely the day for ice edge observations! The MIZEX ice edge was quite compact and following its recent east/west sinusoidal undulations in the easternmost legs. As can be seen in Figure 1, a distinct change in orientation occurred near the middle of the pattern, running from southwest to northeast at a 45 degree slant across our tracks, still compact, and still undulating sinusoidally. To the west, there was clearly evidenced an eddy feature as delineated by the diffuse rings of ice shown on the airborne ESMR image in Figure 1. Just south of that can be seen the so-called "dog's head" feature which gives the impression of ice floes having been projected outwards by the edge of the eddy, at the rate of at least 55 km in two days since these floes were not there during our prior flight two days earlier. The same feature is indicated in the SMMR image for Day 178 (Figure 2), in which the ice edge is shown as a solid line, the ice edge four days later as dashed, and the mosaic location as a box.

Day 180 - 6/30 - Evenes RT -Transects along Ice Edge - A rosette pattern was flown over Nordaustlandet. The remaining time was used to fly a straight-line transect between 80° 20'N, 15°E to 80° 20'N, 5°W. We returned on a parallel line 5 nm north of that to the 0° 30.8'E meridian and headed south to a latitude of 79° 30'N, the predicted location of the northern edge of the eddy. The east/west transect over the sea ice was clear, and afforded the opportunity for some excellent photography of sea ice. The lack of cloud cover also resulted in below-freezing ice temperatures and the strongest multiyear microwave signatures observed on this mission. We were not so fortunate in our attempts to obtain microwave imagery of the large eddy, since it had drifted southwards and outside of the preselected imager swath. It was easily observed visually, however, with about the same eastward extent as before.

Day 182 - 6/31 - Evenes RT - Five-leg East/West Mosaic - Centered at 79° 15'N, 0°W - Clear - The two northernmost legs were extended to ca. 12°E in order to overfly Polarstern. The "dogs's head" ice formation was still intact, although it had drifted about 30 km south and was more diffuse, indicative of loss through melting. Within the mosaic, the pack was quite unconsolidated, with concentrations running 50% or less all the way to the Polarstern.



- Figure 1 -



- Figure 2 -

PRELIMINARY MISSION REPORT
RUTHERFORD APPLETON LABORATORY OPERATIONS ON THE
NASA CV990 FLIGHTS DURING MIZEX 84

R.J.Powell and A.R.Birks, Rutherford Appleton Laboratory

The Rutherford Appleton Laboratory (RAL) has been responsible for the construction of a microwave altimeter/scatterometer and its deployment in a NASA Convair 990 flying Laboratory during the period 7-30th June 84. This work has been undertaken in support of the ESA ERS-1 radar altimeter programme, the Marginal Ice Zone Experiment (MIZEX) and collaborative research programmes within RAL, University College London, Mullard Space Science Laboratorty, Scott Polar Research Laboratory and Oxford University.

The activity has been supported largely by funds from UK Science and Engineering Research Council, who support this team of scientists at RAL and ESA who have provided about half of the flight costs and a study contract under which the resulting data will be analysed.

RADAR ALTIMETER - PRODUCT DEVELOPMENT OVER THE MIZ

It is clear from the flight tracks that a great deal of data was collected in the MIZ. Some points of particular interest are: -

- A line running into the ice from the ship Polarstern was very thoroughly with nadir scatterometric measurements at 13 GHz and photography from a helicopter plus surface sampling. This line was overflown by the altimeter twice at 33,000 ft and once for albido measurement at 500 ft.

- Data for ocean wave spectra determination was collected while passing from the ocean into the ice on several occasions.

- Similarly H1/3 data was collected.

- SAR 580 images were collected on 30th June coincident with RAL H1/3 and wave spectra data.

MEASUREMENT OF σ_0 AND SWH OVER THE OCEAN

Suitable data was collected over the MIZ and on the ferry legs to and fro. However, ground truth is generally only available in the MIZ where ship, SLAR and SAR has been taken with close coincidence.

There is probably no coincident RA, and laser profiler data over the sea so that a wave-bias study will not be possible.

Some information on the variation of σ_0 with altitude may be obtainable from the flights at 500 and 30,000 ft and helicopter data measured in the same region.

Participation in the NOAA P-3 Aircraft in the 1984 Summer MIZEX

L. S. Fedor
NOAA, Wave Propagation Laboratory

The principal investigators participating in the NOAA portion of the 1984 summer MIZEX are L. S. Fedor, J. Overland, D. Ross, and M. A. Shapiro of NOAA and C. T. Swift of the University of Massachusetts. The instrumentation on board the NOAA aircraft included: Ka band SLAR; LASER; C-band step-frequency radiometer; gust probe; up, down, and side radiometers covering from 0.3 µm to 14 µm; cameras; omega drop windsondes; airborne expendable thermographs; and flight-level data. Because of space limitations, the LASER and SFMR could not be flown at the same time. On two of the missions a total of 128 SUS charges were dropped in support of the acoustics research. A total of six research missions were flown, each of approximately 9 1/2 hours duration. The SFMR was on Missions 4 and 5. The LASER was on for the other missions. An ice observer, AGI Carl Newton from the Navy/NOAA Polar Ice Center was on board for all missions.

MISSION #1, 20 June 1984 - BOUNDARY LAYER: Winds in the operating area were generally northerly 6-8 m/s. The wind drag stacks were oriented on the KVITBJORN with the cross-wind legs towards the West. A total of 2 1/2 stacks were completed with the gust probe, SLAR, and LASER all obtaining good data. Only one AXBT successfully transmitted data for calibration of the downward looking PRT-5 radiometer. There was 5/10 ice coverage in operation area nearly all first year ice.

MISSION #2, 22 June 1984 - ACOUSTICS #1: Two long legs oriented North-South and East-West were centered over the KVITBJORN. There were two short legs oriented at 45° and 315° from the KVITBJORN. A total of 64 SUS charges were dropped (two became imbedded in the ice). Only 8 of 16 AXBT's transmitted data. At the ends of the North-West and North-South leg, we encountered 9/10 and 6/10 respectively of multiyear ice. By flying a dog leg we have the opportunity for good directional measurements of multiyear ice by the LASER. A North-South run at 5000 feet was made to give a good survey of the area from the SLAR.

MISSION #3, 24 June 1984 - ACOUSTICS #2: The flight pattern for this mission was a repeat of Mission #2. There was a strong southerly wind of 20 kts onto the ice dropping to 2 kts at the edge of the pack. We had a weight problem with the SUS charges on board and had to leave the gust probe sensors and the engineer in BODO. Again 64 SUS charges were dropped. Of 16 AXBT's dropped, ten transmitted good data. In the open water there was mixed swell conditions--longer swell from the South and shorter swell from the East with some white caps on the surface. Inside the MIZ, where the wind had dropped off, the LASER would lose track going from ice floe to open water which was very smooth. Open water surface temperatures were $\approx 3^{\circ}$C. Rain showers and turbulence were encountered in the eastern and southern parts of the flight pattern.

MISSION #4, 30 June 1984 - REMOTE SENSING SURVEY: A square-wave pattern was flown covering an area 100 nm on a side. The pattern covered an area from outside the MIZ to well into the pack. The northwest corner of the

pattern was over 9/10 MY ice. At least three MIZ eddies were overflown with the largest at the southeast corner. Some swell was observed entering the area from the East, otherwise the water surface was very smooth. The SFMR replaced the LASER on this mission. The survey was flown at 5000 feet except for a 500 foot run diagonally across the pattern for low level SFMR and SLAR data comparison. We dropped four AXBT's in the largest eddy on the last run.

MISSION #5, 4 July 1984 - ICE EDGE SURVEY: The Ice Edge was flown from northeast of SPITZBERGEN to 3°W. The principal instruments were the SFMR, SLAR, and PRT-5. We dropped 15 AXBT's both inside the pack through and outside the MIZ. Visual observations east of the MIZEX operations area were marginal because of heavy low-level clouds. Pack ice was 9/10 MY. A leg was flown in the MIZEX operations area for data comparisons with the U.S. Navy and NORWEGIAN P-3's. West of the MIZEX operations area we encountered mostly FY ice with open water surface temperatures of 4.0 to 4.5°C. Three AXBT's were dropped in the Gulf Stream in returning to BODO.

MISSION #6, 6 July 1984 - METEOROLOGY FLIGHT: A low pressure system moved from NORWAY to SPITZBERGEN on the 5th, 6th, and 7th of July. Strongest effects in the MIZEX operations area occurred late on the 6th. An ODW survey was made from BEAR ISLAND to the MIZEX area with five ODW's. We will need the 12Z soundings from BEAR ISLAND and weather ship AMI. There were strong northerly winds in the operations area but attempts to fly wind stress stacks were foiled by the low cloud base. Nevertheless, we were able to see the surface at nadir and 90% of the LASER data is good. Numerous upwind and downwind legs were flown over the KVITBJORN and POLAR QUEEN. At least one downwind leg was directly over the KVITBJORN. Upon leaving the area, one ODW was dropped at 78.22°N, 2.6°E. A total of five AXBT's were dropped in the Gulf Stream on returning to BODO.

SLAR AND LASER OBSERVATIONS OF SEA ICE DURING MIZEX '84

Duncan B. Ross and John Tomchay

NOAA, Miami, FL

Real aperture radar imagery at 35 GHz and laser profilometery were obtained of sea ice in the marginal ice zone from a National Oceanic and Atmospheric Administration RP3C turboprop aircraft during June and July of 1984. SLARD data were obtained on 20, 22, 24 and 30 June, and 4 and 6 July. Figure 1 presents an example of the characteristics of the MIZ on 20 June in the vicinity of 80.3N and 6.45E during off ice winds of 5-7 mps. The ice consists of small pancake floes fairly well dispersed due to the local wind conditions. Figures 2, 3, and 4 show the MIZ at the same region on 22 June with winds of 1-2 mps from about 40 degrees. The small floes have quickly adapted to the pattern of the surface current regime which displays considerable complexity. Nearby, at 80.45 and 3.27E Fig. 5 shows the more solid pack to be heavily rotted, with many small floes broken off the larger multiyear floes. Fig. 6 presents evidence of another well developed eddy structure at 78.9N and 2.44E. The surface wind of 4 mps was blowing essentially off ice (from 340 degrees).

Laser profilometry data were obtained on 20, 22, and 24 June, and 6 July. The data were generally of high quality and included the laser altitude, phase shift, and signal amplitude signals. The data were recorded digitally at a frequency of 80 samples per second.

High quality imagery and profilometry have been obtained over the MIZ which will allow objective determination of ice concentration and roughness. The imagery were obtained at various altitudes which may allow development of algorithms to extract ice age information. Ocean surface current patterns were imaged through their ice signature. Wave conditions were generally too benign to image, but some imagery of waves within the MIZ boundary were obtained.

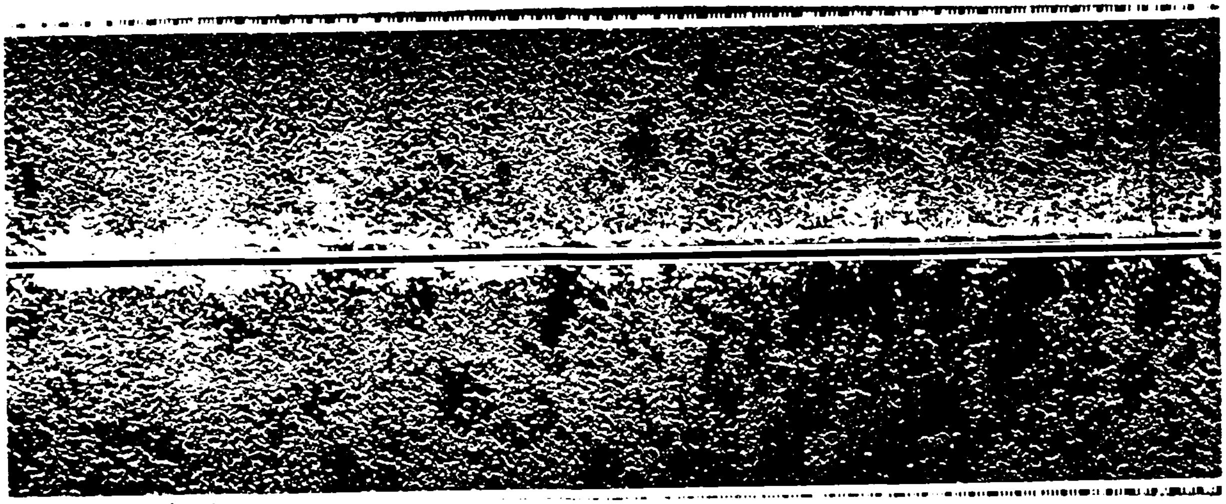


FIGURE 1. 20 June 1982. 80.3N. 6.45E. Altitude 50M. Range [illegible]

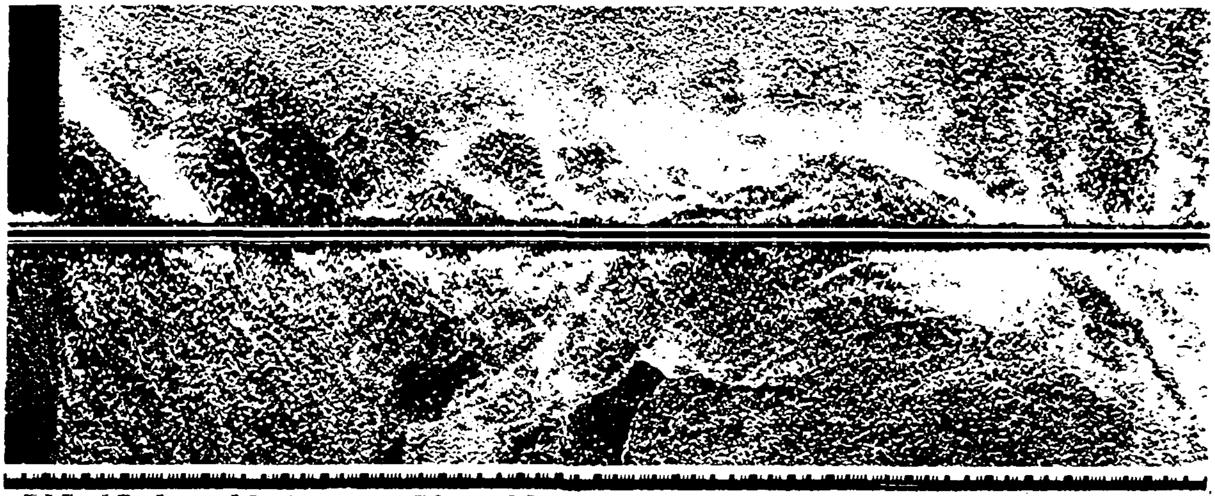


FIGURE 2. 22 June. 1984. 80.3N: 5.5E. Altitude 77M. U10=2 [illegible]

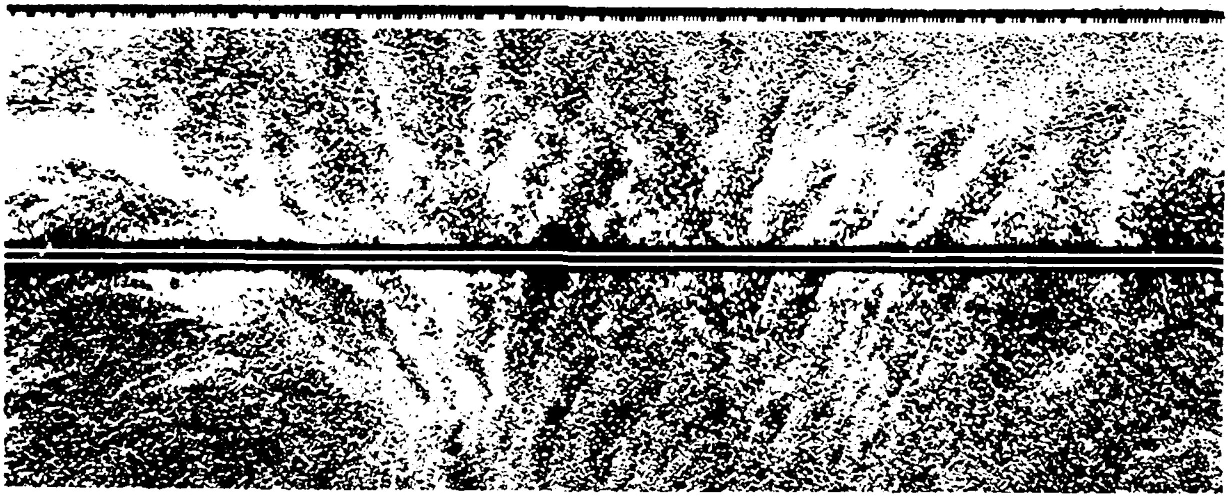


FIGURE 3. 22 June 1984. 80.3N; 6.25E. Altitude 145M. U=2mps.

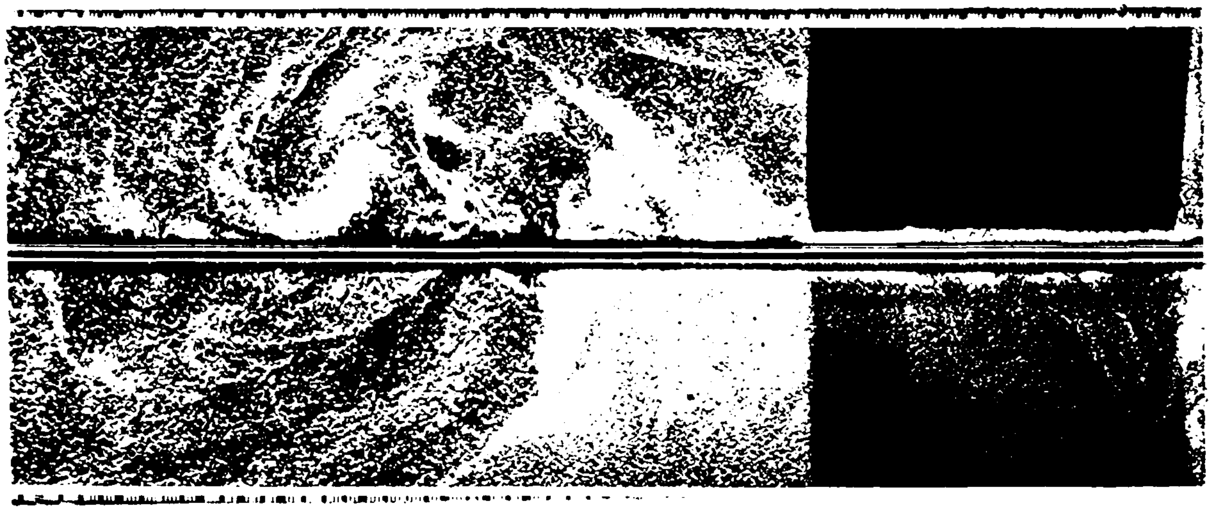


FIGURE 4. 22 June, 1984. 80.23N; 3.47E. Altitude 145M. U10=2-3mos

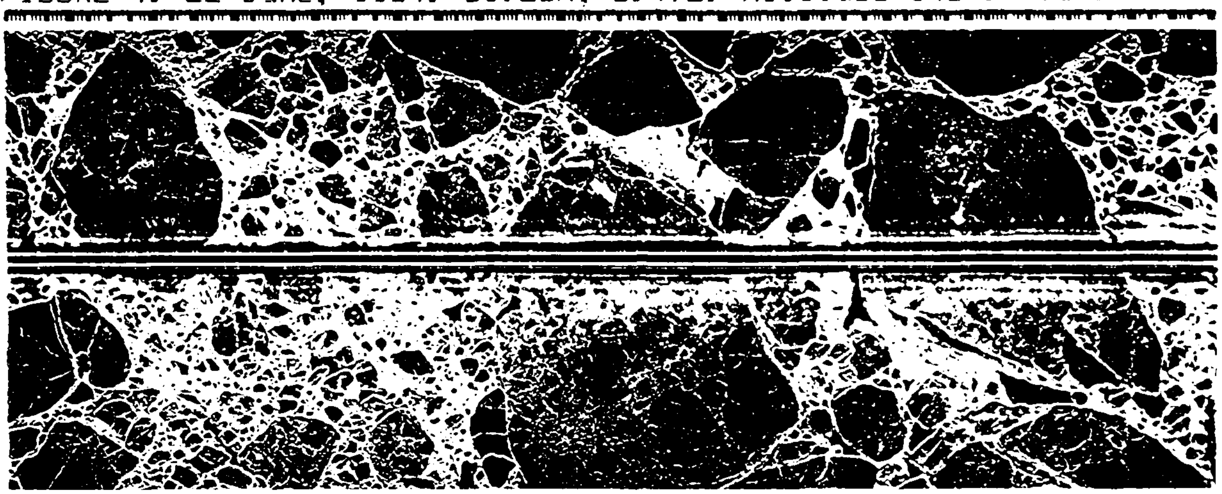


FIGURE 5. 22 June 1984. 80.45N; 3.27E. Altitude [illegible]45M. U10=[illegible]-3mos

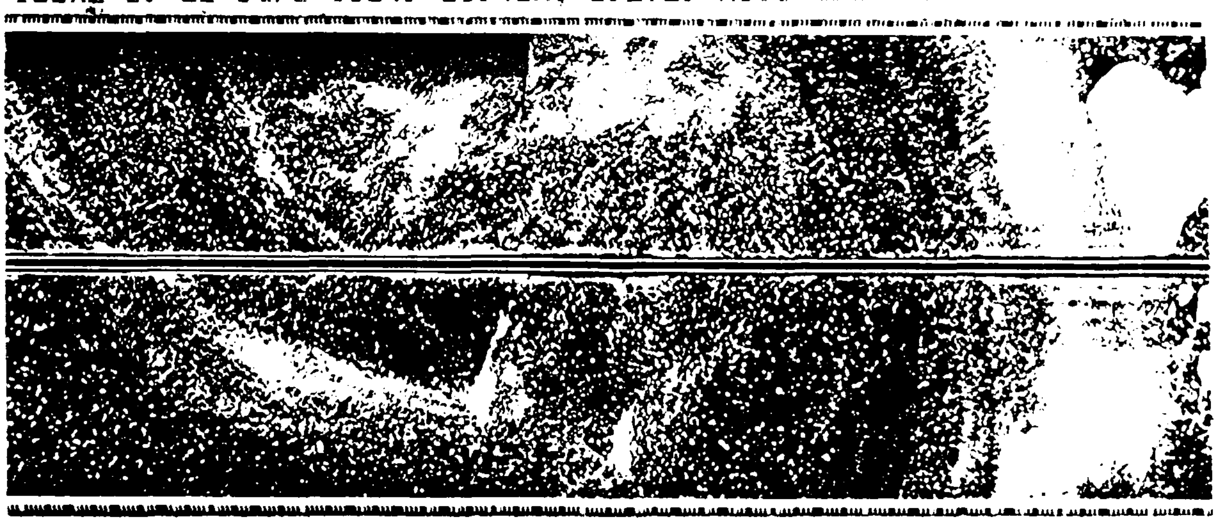


FIGURE 6. 30 June, 1984. 78.9N; 2.4E. Altitude 1500M. U10=4-5mos

ACTIVE MICROWAVE MEASUREMENTS OF SEA ICE IN THE MARGINAL ICE ZONE

R.G. Onstott and R.K. Moore
Remote Sensing Laboratory
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Lawrence, Kansas 66045-2969

The primary objective of the near-surface radar backscatter measurement program was to describe the scattering coefficients of sea ice and ocean in the marginal ice zone (MIZ) in order to understand their influence on the microwave properties of ice and ocean in the region. These and physical property measurements were coordinated with the active and passive microwave aircraft measurement program. Radar backscatter data were acquired, using the University of Kansas helicopter-borne scatterometer (a calibrated radar) at 5.2, 9.6, 13.6 and 16.6 GHz, at multiple angles from 0° to 70°, with VV, HH and HV transmit-receive antenna polarizations. In addition, a calibrated radar operating at 1.5 GHz and HH-polarization was installed on the icebreaker "Polarstern". Its viewing angles ranged from 17° to 50°.

Sites investigated included small-to-vast first-year, thick first-year and multiyear ice floes which were visually representative of ice types in the MIZ and pack ice region. Ice thicknesses ranged from 30 to well over 300 cm. Snowpack was heavy, with depths up to 60 cm on many multiyear ice floes. During the experiment period the snowpack and ice sheets underwent a transition from early-summer to summer-melt conditions.

Auxiliary measurements, to be used in the study of the radar altimeter response of sea ice and ocean, were made with a vertical look angle at 5.2 and 13.6 GHz. Additional measurements, transects, were made to study the relationship between the radar response and ocean phenomena such as fronts at the leading ice edge and eddies, as well as the relation between the radar response and ice concentration.

General ice condition descriptions, oblique photography, and detailed descriptions of snowpack construction were made in support of near-surface and aircraft observations.

ICE MICROWAVE REMOTE SENSING EVALUATION PROGRAM

Prime Investigator: C.Schgounn (lrance)

Three active sensors have been involved in the remote sensing program. The overall purpose was to make measurements at different scales in time and space to study radar signatures of various ice-type during summer months at different frequencies, polarizations, angle of incidence.

I RAMSES PROGRAM
Instrument manager: E. CHAPUIS.

The ground based frequency modulated radar RAMSES II on Polarstern will provide in situ measurements for the whole period on different ice-conditions. Mesurements have been done at 5.3, 9.4, 13.6, 16 GHz for like polarizations during stations in the ice.During each station one to six curies from 0 to 60 degrees of incidence have been obtained . Data are summarized in table 1 - pictures of surface during stations are available.

II ERASME PROGRAM
Instrument manager: E. CHAPUIS

Measurements with the frequency modulated radar ERASME working at 5.35 GHz on helicopter AS 355 have been done along tracks approximately 200 km long. The purpose is to study ice/water transitions, ice/water concentration and ice characteristics. Each track corresponds to a given incidence and polarization. Video recordings have been correlated with flights.
Data are summarized in table 2.

TABLE 1

Date	Lat.	Long.	5.3		9.4		13.6		16	
			HH	VV	HH	VV	HH	VV	HH	VV
169	79.17N	3.29 W					x	x		
171	80.80N	3.13 E			x	x	x	x		
171	80.80N	3.04 E			x	x	x	x	x	x
173	80.32N	6.52 E			x	x	x	x		
174	80.14N	2.57 E					x	x	x	x
175	80.12N	2.57 E					x	x	x	x
175	80.11N	2.52 E					x	x		
175	80.80N	2.17 E					x			
177	80.13N	2.03 E					x			
177	80.13N	2.03 E					x			
177	80.10N	1.59 E					x	x		
178	80.20N	1.00 E					x	x		
178	80.20N	2.13 E			x	x	x	x		
179	80.22N	1.26 W			x	x	x	x		
180	80.39N	5.36 W			x	x	x	x		
180	80.35N	5.24 W					x	x		
180	80.20N	3.22 W					x	x		
182	79.23N	10.41 W		x	x	x				
183	79.25N	4.17 W	x		x	x				
183	79.2 N	2.48 W	x		x		x			
185	80.24N	1.17 E	x		x		x		x	
186	80.19N	1.29 E				x	x	x		
187	78.25N	00.28 E					x	x		
188	78.25N	05.04W	x		x		x			
189	78.41N	2.19W	x		x		x	x		
190	78.56N	1.25 W	x		x		x	x		
191	79.36N	6.38 W	x		x		x	x		
192	79.31N	6.26 W	x	x		x	x	x		
193	79.41N	6.41 W	x	x	x	x	x	x		
194	79.47N	5.32 W	x	x		x	x	x		
195	79.48N	5.28 W	x	x	x		x	x		
196	79.47N	3.53 W		x			x	x		
197	79.36N	1.22 W		x	x	x	x	x		
198	79.00N	00.39 E		x	x	x	x	x		
198	79.12N	00.08 W	x	x	x	x				

Date 180	Incidence 27°	Pol VV		Alt. 1100 f.
1 track	Lat. 82.19 N	Long. 04.25W	to	03.00 E
2 track	Lat. 80.30 N	Long. 03.00E	to	03.30 W
Date 180	Incidence 10°	Pol VV		Alt. 1100 f.
1 track	Lat. 80.20 N	Long. 04.25 W	to	03.10 E
2 track	Lat. 80.30 N	Long. 03.04 E	to	04.25 W
Date 182	Incidence 5°	Pol VV		Alt. 1100 f.
1 track	Lat. 79.15 N	Long. 08.20 W	to	02.00 E
2 track	Lat. 79.15 N	Long. 02.00 E	to	08.20 W
Date 182	Incidence 40°	Pol VV		Alt. 1100 f.
1 track	Lat. 79.15 N	Long. 10.28 W	to	00.00
2 track	Lat. 79.15 N	Long. 00.00	to	10.28 W
Date 188	Incidence 25°	Pol HH		Alt. 320 f.
1 track	Lat. 78.24 N	Long. 05.27 W	to	00.50 W
2 track	Lat. 78.24 N	Long. 00.50 W	to	05.27 W

TABLE 2

UNIVERSITY OF WASHINGTON MICROWAVE EMISSION PROGRAM

Thomas C. Grenfell

Surface based observations of radiometric brightness temperatures over sea ice were carried out from 8 June through 16 July from M.V.Polarqueen. Measurements were made at frequencies of 6.7, 10, 18.7, 37, and 90 GHz in both vertical and horizontal polarization as a function of position along horizontal traverses of 50 to 200 meters in length and as a function of nadir angle at indivdual sites. Twenty three different sites were investigated over the course of the experiment. Unfortunately, the Gunn diode in the 37 GHz instrument burned out during the first week, and we were not able to repair it on site. Thus 37 GHz data could not be obtained after that time.

Measurements were made over the range of surface types encountered. These included both bare and snow covered ice from cold conditions (-7 to -10°C) through to melting summer ice. Multiyear, thick first-year and frozen lead surfaces (identified last year as thin first-year ice) were studied. Observing times were chosen specifically to coincide with overflights by the NASA CV990, the NRL P3, and the CCRS CV580 aircraft. This effort in turn was carried out on even days of the month in order to coincide with scheduled SMMR imagery.

In conjunction with the radiometric observations, an extensive program of surface characterization was carried out. Along each of the radiometer traverses, detailed studies were made of surface topography, spatial variations in snow depth, the occurrence of ice layers and lenses in the snow pack, and ponding of meltwater. These were compared with the corresponding radiometric records. At selected locations, surface characteristics were determined from core samples. For cold ice cases, these measurements included temperature, salinity, and density profiles in the snow and the top 30 cm of the ice together with the geometry and mean size of the snow grains. When the ice entered the transition to melting stage, free water content measurements in the snow and loose upper layers of the ice were included in the program. The crystal geometry and density of the loose granular layers were also obtained.

At the snow/ice interface, salinities near zero were found even during the cold weather suggesting that prior melting events had taken place in the marginal ice zone. This conjecture was supported by the presence on the first drift floe of extensive snow free areas with a smooth surface and recrystallized structure in the upper few centimeters of the ice. As a result, the ice tended to show a multiyear-like signature (brightness temperature decreasing at higher frequencies) over certain areas of the first-year ice.

Early in the experiment, pressure ridges and compacted snow drifts showed a decreased brightness temperature most notably at the higher frequencies. Later in the season, these areas often responded faster than the surround-

ing level ice to diurnal fluctuations in the net surface energy balance resulting in spatial variations of up to 10K of both positive and negative sign depending on the time of day. Future analysis will involve detailed correlation studies of this behavior.

DATA REPORT ON VARIATIONS OBSERVED IN THE COMPOSITION OF SEA ICE DURING MIZEX'84 USING THE NIMBUS-7 SMMR

Per Gloersen

In support of the Marginal Ice Zone Experiment in the Fram Strait region of the East Greenland Sea in June/July 1984 (MIZEX'84), the Nimbus Project at the NASA Goddard Space Flight Center provided researchers in the field near real-time images of the sea ice concentration and age, and of near-surface winds over the open ocean. These images, calculated from SMMR radiances, were transmitted by means of electronic mail. Subsequently, these data will be analyzed along with the surface temperature information in an attempt better to understand known errors in the sea ice properties calulations near the melt point of sea ice.

Nimbus-7 SMMR data are recorded onto on-board spacecraft tape recorders during the course of an orbit for subsequent higher data-rate telemetering to various satellite receiving stations situated in various places on the globe. For logistical reasons, the station at Gilmore Creek, Alaska was the only one suited for near real-time transmission of the data over land links to Goddard Space Flight Center (GSFC), where the ground station is located. Thus, the data were available at GSFC in as little as one hour after the satellite tape dump, which generally consisted of more than one orbit's worth of information. Because of power constraints on the spacecraft, the SMMR is operated only every other day.

As received at GSFC, the data contain information from several of the instruments on board the Nimbus-7. Furthermore, these data are not earth-located, are in a format designed for efficient and reliable telemetry, and are unsuitable for automatic data processing on standardized computer operating systems. Thus, a data formatting, earth location, and calibration process is required before the SMMR data can be analyzed. This real-time processing required the utilization of predicted ephemeris data for the Nimbus-7 which, in principle, are not as accurate as the definitive ephemeris, based on actual orbital elements (used in the normal SMMR data processing). However, no noticeable location errors have been observed on the real-time SMMR data.

The final stage in this process consists of calibrating the SMMR data, remapping the radiances onto a standard polar projection, performing the calculations of the sea ice properties, mapping the results on the same projection, and producing an ASCII-character representation of that map suitable for transmission on electronic mail. The ASCII-character maps of sea ice properties and winds were produced on the in-house computers at GSFC and stored on disk. The disks were then interrogated by a desk-top microcomputer and stored locally in word processor files on floppy disks. The data were briefly reviewed at the local terminal, edited as necessary, and transmitted via electronic mail to members of 'smmrmizex.list'. The average time between acquisition of the data from the last desired SMMR orbit of the day and the transmission via electronic mail was ten hours, with a six-hour minimum actually achieved. In principle, a much shorter time is possible, but not without risk to the main ground station task of assuring reliable data acquisition for the standard production scheme or inordinately

high processing costs.

The process of calculating sea ice properties begins by forming two dimensionless parameters from selected SMMR radiances to reduce the effects of physical temperature of the sea ice on the calculations. These are the polarization (PR) at a wavelength of 1.7 cm and a spectral gradient ratio (GR) with the use of the vertically polarized channels at the 0.8 and 1.7 cm wavelengths:

PR = (1.7V - 1.7H)/(1.7V + 1.7H)

GR = (0.8V - 1.7V)/(0.8V + 1.7V)

In the vicinity of sea ice of varying age, these parameters are nearly orthogonal in that PR is approximately zero for all types of sea ice and 0.3 for calm open water in clear weather, and GR is near zero for first-year or younger sea ice whereas it is near -0.15 for old (multiyear) ice. This results from the wavelength-dependent volume scattering of microwave radiation in the freeboard portion of multiyear sea ice, which is not present in first-year and younger ice. The scattering is greater at shorter wavelengths. (Over open water, GR is also positive.). Thus, we calculate total sea ice concentration (C) and multiyear sea ice concentration (F*C, where F is the fraction of ice present that is multiyear) as follows:

C=(70.2-267*PR)/(53.2-6.4*F+(200+70.4*F)*PR) ('*' denotes multiplication)

F*C=(30.7-33.1*C-(368+113*C)*GR)/(27.0-91.0*GR)

These equations are recursive to take into account a slight dependence of polarization on the age of the ice and the presence of open water when making the calculation for F*C. The coefficients were calculated by selecting ostensibly pure-sample tiepoints for multiyear ice (a large area northwest of the Queen Elizabeth Islands), first-year ice (a large area in the Chuckchi Sea), and open water with low wind and clouds. The success of retrievals based on this algorithm depends to a large extent on the judicious choice of the tie-points. While those chosen here generally perform well in the Arctic Basin, retuning of the algorithm may be appropriate in other areas. At any rate, these algorithms were used for this study of summer sea ice in the MIZ.

An example of the total sea ice concentration (C) calculation made during this time period is shown in Figure 1 in the ASCII-character format transmitted to MIZEX observers in the field. Here, C is given in even deciles by numerals, with the odd deciles 1 through 9 represented by '-,=,.,/,+' in order to facilitate viewing the isopleths of C on the grid-print map. In Figure 1, the ice edge has been drawn in as a solid line. The ice edge from four days earlier is indicated by the dashed line. Persistent high winds in the area cause much of the open ocean shown here to be covered with '-''s, since the effect of high winds is to depolarize the microwave radiances emanating from the ocean surface; however, some of the open ocean is shown as blanks, indicating calm seas as used for the ocean tiepoint. These data can also be displayed as grey-scale images. Figure 2 illustrates how such an image would appear (using 1983 MIZEX/SMMR data, since such images are not yet available for 1984).

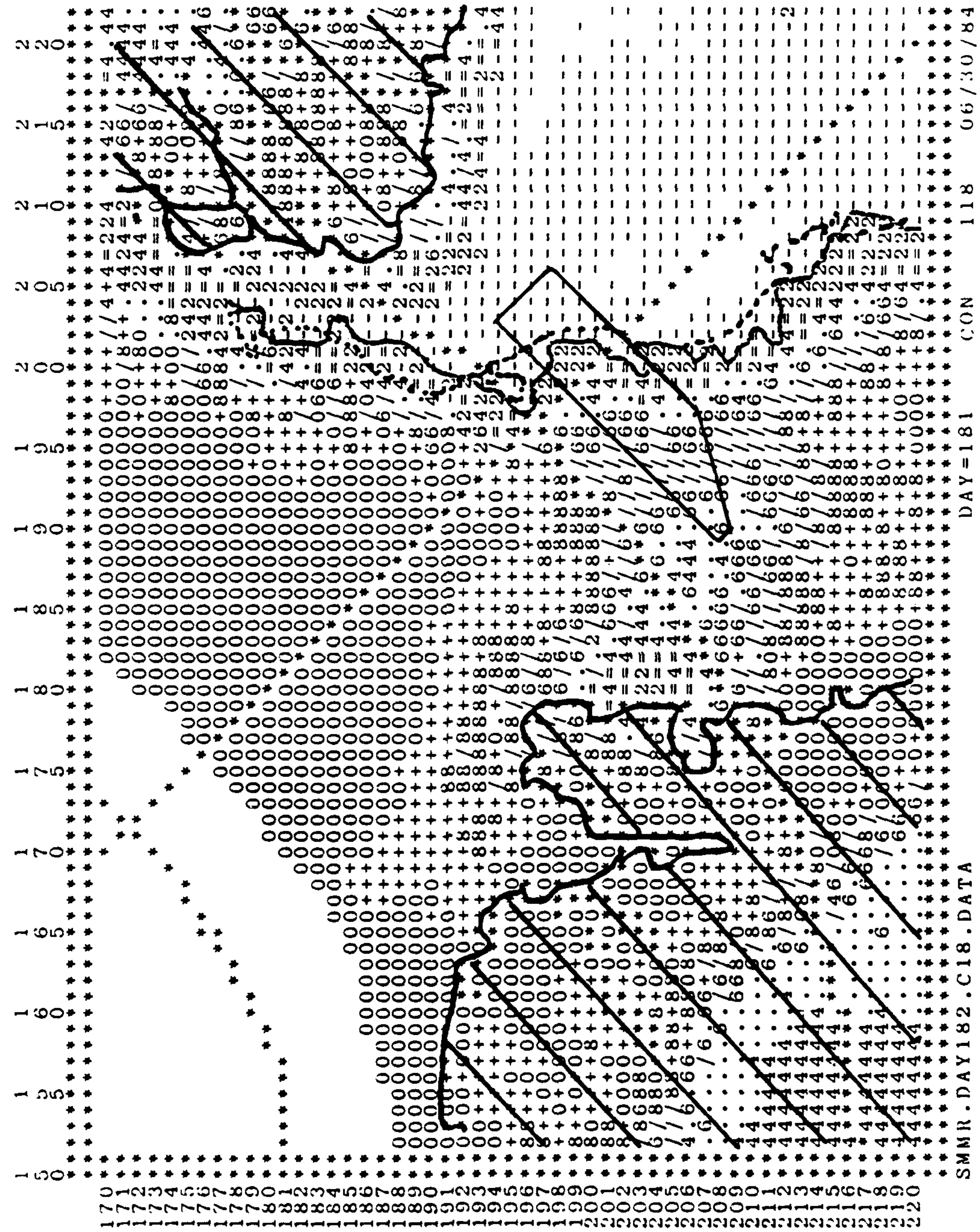


Figure 1.


293 X 293 NORTH POLAR MAP DAY 179 C37
IMAGE# 75 28 JUN 1983 -- 37 GHZ CONCENTRATION *
≥ 90%
70-90%
50-70%
30-50%
10-30%
< 10%
0

Figure 2.

SATELLITE AVHRR IMAGES FOR MIZEX 84

Ola M.Johannessen, Geophysical Institute, Univ. of Bergen
and Kjell Kloster, Chr. Michelsens institute, Bergen.

During Mizex-84 AVHRR-data in the form of Quick-looks and digital tapes have been obtained through Tromsø Staellite Telemetry Station. The coverage on a daily basis is almost complete between May 07 to August 11. A data report entitled "Satellite AVHRR Images for MIZEX 1984 Fram Strait Experiment" by Kjell Kloster has been printed and is available.

ACOUSTICS

MIZEX 84: SUMMARY OF ACOUSTICS PROGRAM

Arthur B. Baggeroer and Ira Dyer

The Acoustics Program was conducted using Kvitbjorn, Sverdrup, Lynch and Polarqueen plus several helicopters and fixed wing aircraft. Personnel from MIT, WHOI, NRL, and NUSC participated aboard ship. The scientific elements are summarized herein.

The acoustics efforts aboard Kvitbjorn centered upon use of a self-locating horizontal array drifting on the ice floes and a vertical array deployed from the ship. In addition, a high frequency array and a telemetry system for scattering measurements were deployed. The horizontal array could accommodate 24 channels; however, the very high rate of ice divergence prevented full deployment and resulted in 15 to 17 hydrophones being operative at a time. The remaining data channels were filled in with sensors from the vertical array. The vertical array operated successfully with 28 of 30 channels; however, there is a modest amount of ship noise on the upper channels except during the time when the ship power was off.

The acoustics efforts aboard Sverdrup centered upon a line array fixed to the bottom off Svalbard in open water. Some difficulty was encountered in acquiring data from all sensors on the array, but data of high quality and usefulness nevertheless were obtained. Also, the program was somewhat foreshortened by adverse sea conditions early in the program and by interference from a non MIZEX ship operating close by near the end.

Lynch and Polarqueen acted as source ships for the Acoustics Program. Also Lynch deployed and recovered a source which was fixed to the bottom, and which was used for pre-tomography and transmission experiments.

Acoustic transmission

Signals from the HLF-3, two mid-frequency sources, and SUS shots deployed from the Polarqueen were recorded extensively aboard Kvitbjorn. In the early part of the experiment the Polarqueen was 40 km distant, so the SNR was very high. After she redeployed because of the deteriorating ice conditions near her she was 80-100 km distant, so the SNR was lower, and more appropriate for study of long range propagation. Signals from the Lynch (HLF-3 and SUS shots) were recorded over a large set of ranges in her track. The signal quality was good except for the most distant ranges. Two NOAA P-3 flights dropped SUS charges and made laser ice profiles in support of the transmission experiments. The suite of signals recorded are over a wide range of conditions representative of MIZ propagation.

Signals from the Lynch, Polarqueen, and the bottom-fixed source were recorded aboard Sverdrup. A large set of transmission ranges resulted from the Lynch track, appropriate for study of both short and long range transmission.

Acoustic tomography

Signals from the bottom-fixed source were recorded on both the horizontal and vertical arrays at Kvitbjorn. A special system for the tomography signals, the DIBOS recorder, did not function properly. Fortunately, the digital system and analog system recording bandwidths

cover the frequency band, so data can be recovered from them.

Seismic refraction and acoustic impulse response

Three lines, two along the crest of the Yermak Plateau and one normal to it, were shot with 1 km spacing to offsets of 20 km, and recorded aboard Kvitbjorn. There was not enough ice for landing the helicopter to permit shooting reversed lines. SUS charges were also deployed during the seismic refraction lines for impulse response measurements. These lines were supplemented with two additional ones solely for impulse responses.

Seismic refraction lines near Sverdrup were not successfully recorded. The shot sizes were too small to overcome noise at long ranges and too intensive for the recording dynamic range at short ranges.

Seismic reflection

Three days of seismic reflection with a 40 cu in air gun were done from the Kvitbjorn. Only 3-5 sensors were then active because the Kvitbjorn had to reenter the ice edge after drifting into open water. The drift track during this phase overlapped parts of the seismic refraction lines on the Yermak Plateau.

Ambient Noise

Extensive recordings of ambient noise were done both at the Kvitbjorn and remotely via helicopter and sonobuoys. The recordings at the Kvitbjorn were done by turning off the ship's power and running solely on a 12 kw generator. Both horizontal and vertical array sensors were used, so angular dependencies can be determined for frequencies below 250 Hz. Wideband ambient noise data to 2 kHz were recorded on analog tapes, and spectral samples to 50 kHz were measured in real-time. Remote measurements were made by installing a spectrum analyzer, tape recorder and plotter on the helicopter and powering them with a small generator. Point measurements were made along the ice edge and normal to it for ranges of 80 km from the Kvitbjorn. Three Norwegian P-3 flights using 57A sonobuoys were also used to record ambient noise data. The crew indicated that "high quality" recordings were obtained. Ambient noise was also recorded aboard the Sverdrup.

Reverberation and backscattering

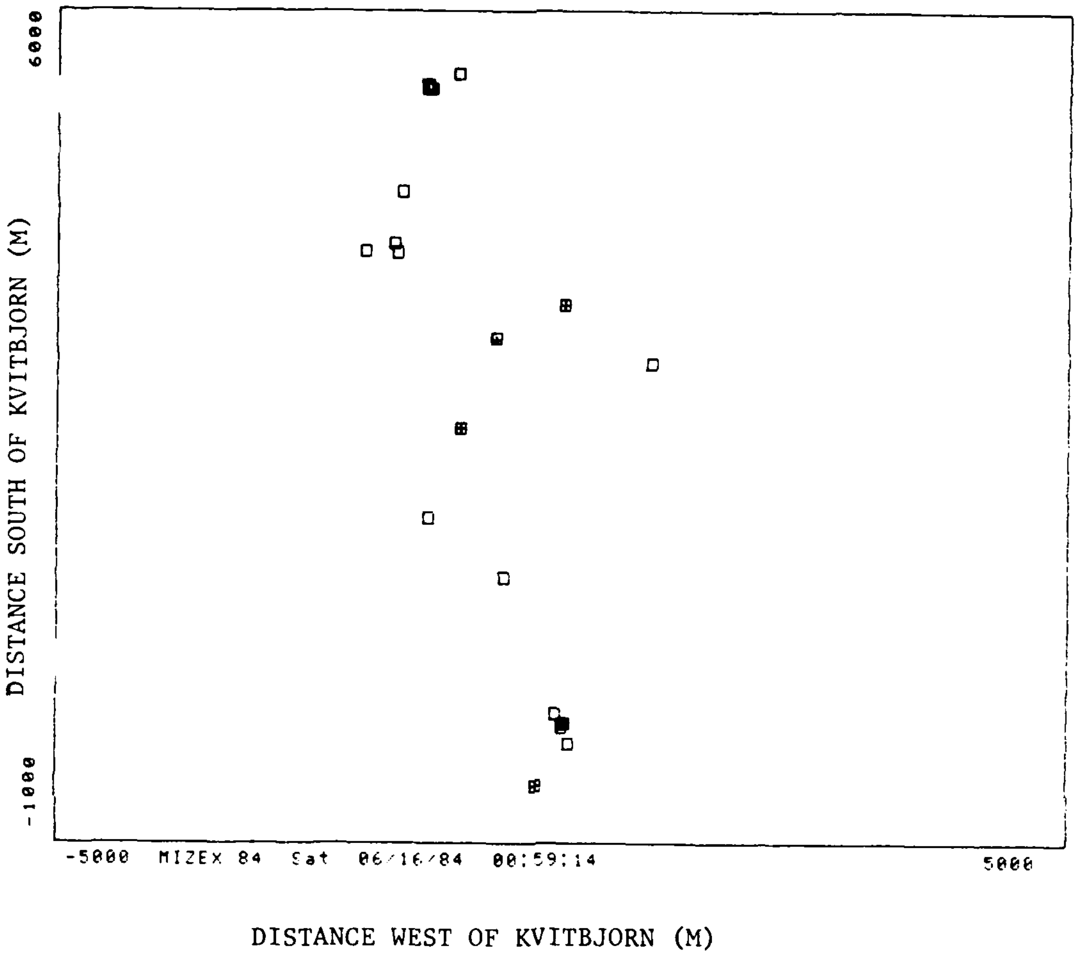
Three 100 kg explosions for measuring low frequency reverberation and ice backscattering were deployed and recorded successfully aboard the Kvitbjorn under quiet ship conditions.

Acoustic telemetry and hf scattering

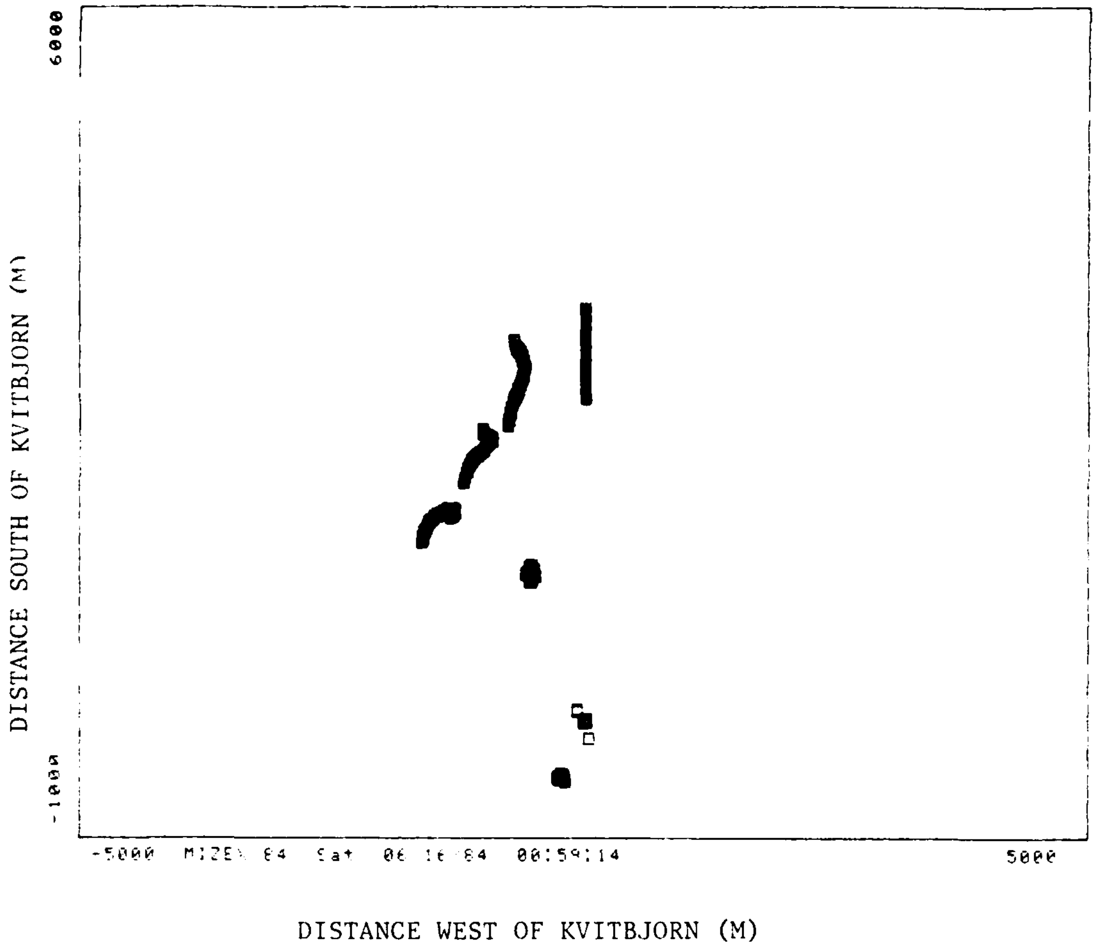
Two sets of 50 kHz acoustic telemetry data over 1 km range were recorded at the Kvitbjorn. These data will be useful in characterizing ice effects on hf acoustic signals as well as on performance of the telemetry system beneath the ice canopy.

Ice kinematics by acoustics

The self-locating capability of Kvitbjorn's horizontal array provided tracking of the ice from individual sensor motion. See attached figures for a tentative result. Headings and fixes were logged concurrently so absolute positions can be estimated to within rotation of the array; however, during periods of rapid motion the sampling may not be adequate. Radar reflectors were not effective and the sensors were often not in visual distance of the ship, thus eliminating a useful check.



Sensor positions determined in real time June 16, 1984 during the MIZEX 84 experiment. Kvitbjorn is in group of sensors near bottom of plot.



Drift tracks of selected sensors for 150 minutes prior to previous plot. Kvitbjorn is reference (0,0) location

MIZEX 84 CRUISE REPORT
KVITBJORN: FIRST LEG 2 June - 30 June
IRA DYER

MIZEX 84 in overall was a complicated operation, entailing a large number of scientific objectives, scientists, ships and aircraft. Kvitbjorn's role was largely related to acoustics, which required close collaboration with Lynch, Sverdrup, and Polarqueen, and with several helicopters and fixed wing aircraft. Kvitbjorn also included smaller programs in oceanography and meteorology. Coordination of Kvitbjorn's programs with the larger objectives of MIZEX 84 showed daily evidence of difficulties and irritations, but it is a credit to Ola Johannessen and his management team that MIZEX 84 worked. If there is a simple formula describing this positive outcome, it would relate to detailed planning, dedication to scientific objectives, flexibility under constraint, and mutual understanding.

The at-sea communications burden was immense, but necessary. This burden entailed much more than the Acoustics Program; indeed it can be said that radio communications with the Kvitbjorn involving strictly acoustics science was much smaller than communications involving the remainder of the program. The time budget each day on average was approximately:

- 0500 voice reporting: 2 hours
- 1900 voice reporting: 1 hour
- 2000 Telex reporting: 2 hours

To this budget we should add approximately 1 hour/day for miscellaneous voice communications with other ships on special operational or scientific questions. Thus, about 6 hours per day were devoted to radio communications, requiring one of our senior staff to be on the bridge instead of attending to science.

Aircraft operations placed a large additional burden on our staff, since helo operations entailed continuous radar and radio contact. Kvitbjorn's helo averaged 4 hours/day of actual flying time plus <u>at least</u> 4 hours/day of remote on-ice ti·e (that is, with the helo shut down at a remote station while instruments were deployed, maintained, data taken, etc.). Thus one of the staff also had to devote an average of at least 8 hours/day of bridge time to keep the helo going. Coupled with this were frequent overflights of the NOAA-P3, the Norwegian P3, the CV-990, the CV-580, the Falcon, and other helos from the Polarqueen, Polarstern, and Svalbard. Fortunately most of these other flights occurred when Kvitbjorn's helo was operating, creating no additional time burden on our staff. Unfortunately, none of us was really prepared for air-traffic control work; we now know first-hand why many controllers develop ulcers and nervous breakdowns.

In retrospect we should have had a PSC logistics person with us to take on the 14 hour/day burden of radio communications and air traffic control. As it turned out, this burden affected the science program through inadequate rest, and through less real-time reduction of data than we would have liked.

Navigation data for the first leg of Kvitbjorn are summarized in the attached figures, and cover Julian day 157 (5 June 1984) to Julian day 182 (30 June 1984), which go from the first in-ice day to the return to Longyearbyen for rotation and resupply. Position data were initially obtained by hand logging of the ship's satellite navigation receiver, and linearly interpolated. At Julian day 171 another receiver was brought on line which could be logged directly by our computer.

In brief, Kvitbjorn occupied several drift stations during the leg. As the position data show, the general drift direction was south which put us at times too close to the ice edge or at a position of too low ice concentration. The need to move back to better ice conditions, requiring recovery and then redeployment of equipment, caused interruptions in all Kvitbjorn science programs. Further, since Kvitbjorn does not have a helo pad, we depended upon adjacent ice floes as pads, which caused additional logistic delays during repositioning. (During one repositioning Kvitbjorn proceeded slowly north, dragging the helo's ice pad with us.)

We elected to rotate science crews by transit to Longyearbyen, rather than via Svalbard helicopter as originally planned. The underlying rationale for this change was the desire to occupy CTD stations south of the ice edge to assist in measuring an eddy which had been discovered by others. (We also took this opportunity to deploy XBTs while underway and to continue float tracking while on station.) Ship's resupply as well as crew rotation was simplified by this change.

On balance, Kvitbjorn's capabilities served us well. A larger ship could have punched further into the ice. But a larger ship would have entailed programs interferring with quiet ship requirements. Quiet ship entailed shut down of <u>all</u> ship's machinery. A specially isolated motor generator supplied power for the acoustics' equipment.

Kvitbjorn's skipper and crew supported us with enthusiasm and skill. They genuinely seemed to enjoy the challenge of our mission compared to the usual routine of fishing, and they creatively improvised mechanical and/or electrical solutions to our many shipboard problems. And since it can be said that Arctic experimentors rely as much on their stomachs as their heads to get good data, Kvitbjorn's cook and stores served us exceptionally well.

The helo pilot and mechanic also supported us with enthusiasm and skill. Because flying weather rarely was a detriment, the helo would fly whenever we needed to even though the duty time might have stretched well beyond normal. (We never violated the limit of 8 hour/day <u>flying</u> time; duty time would go beyond 16 hours on many days.) The pilot was eager as we were to get on with our science.

The Kvitbjorn was well served by PSC in Tromso prior to departure, at sea in arranging for special delivery of replacement navigation and radio equipment, and in Longyearbyen upon return. Tromso served as a valuable shore-based radio contact for operations, for reporting, and for weather forecasts during the leg.

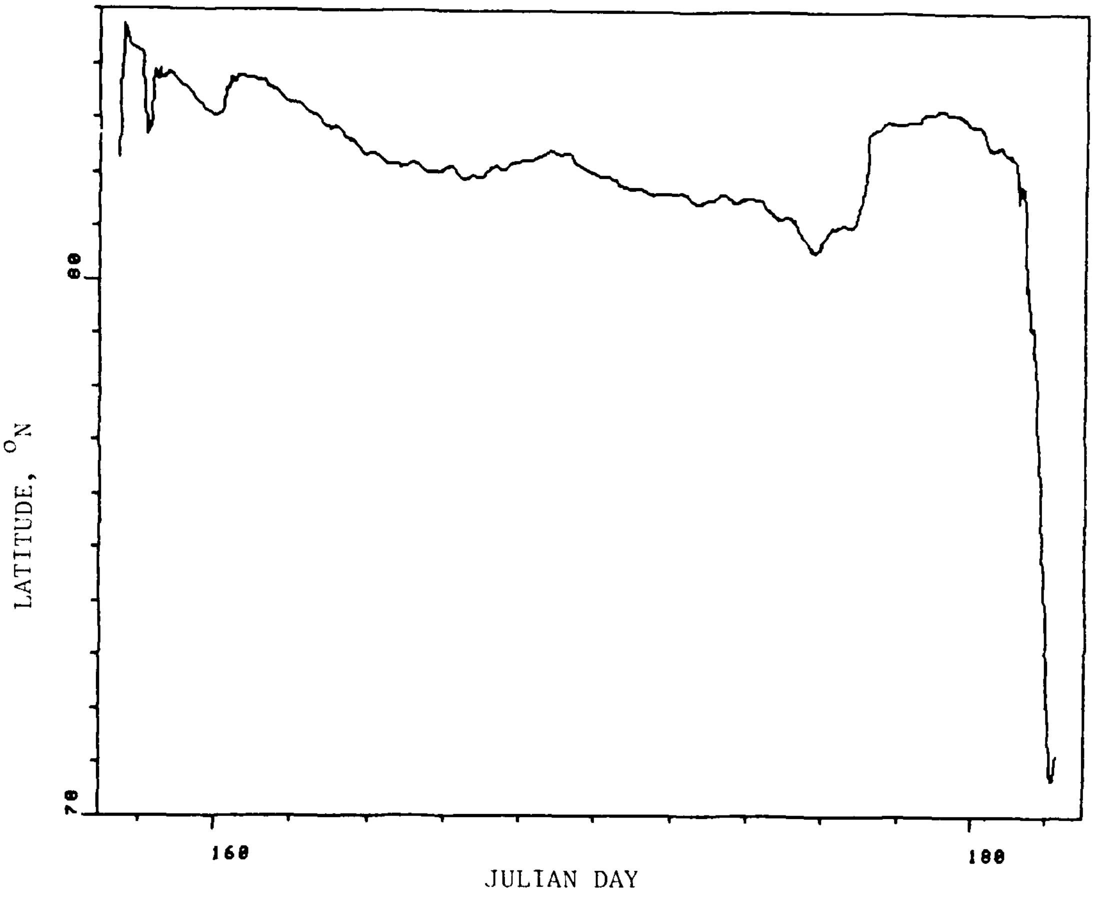


Fig. 1: Time series of latitude position, linearly interpolated.

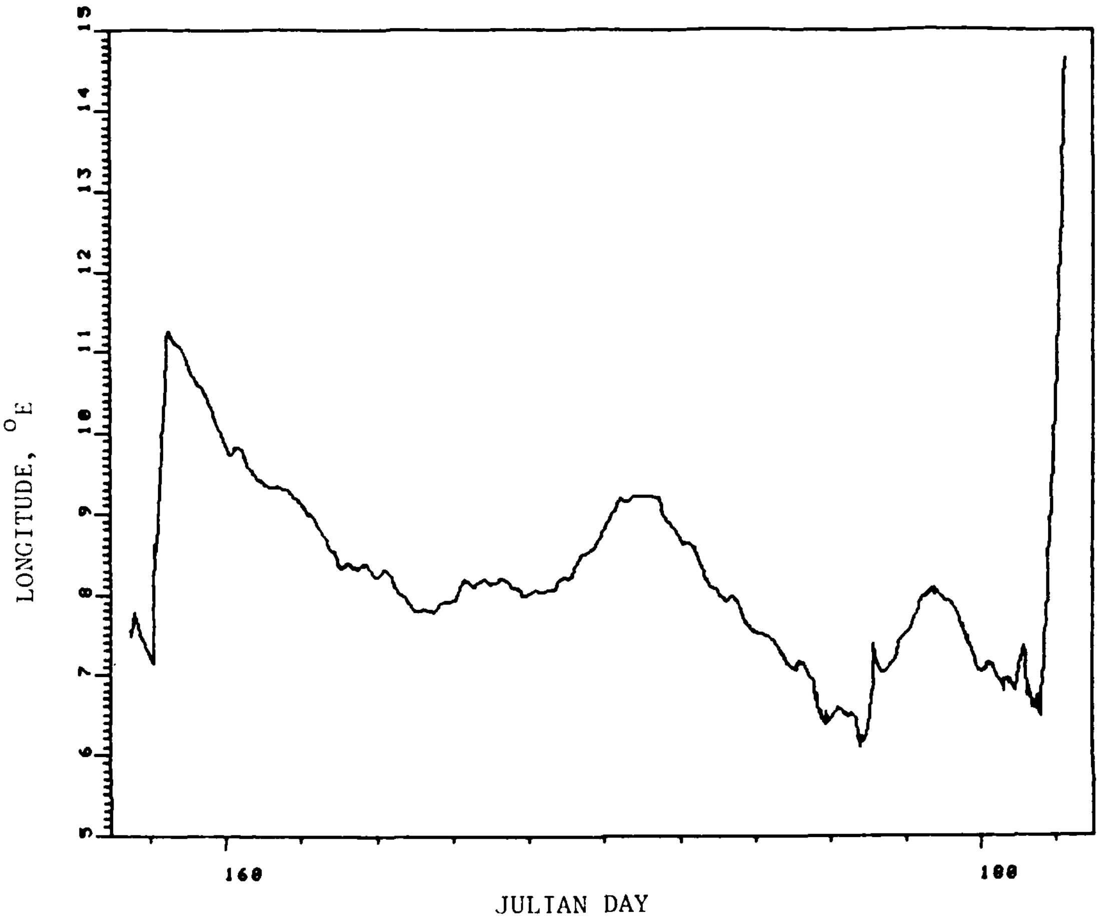


Fig. 2: Time series of longitude position, linearly interpolated.

Vertical Array Acoustics

Ronald L. Dicus, US Naval Research Laboratory, Washington DC, 20375

The time/space coherence of underwater sound propagating in the Marginal Ice Zone (MIZ) is degraded in part by scattering from the underside of rough ice floes. In the MIZ the nature of the underice surface is highly variable both temporally and spatially. Although other characteristics of the propogation channel such as the multipath structure, the ocean bottom, and time/space fluctuations of the sound-velocity profile may be expected to contribute to coherence losses, the Naval Research Laboratory (NRL) has as its primary objective to focus on the acoustic ice interaction and in particular those aspects that may be measured with a vertical array. To pursue this objective NRL deployed a vertical array from M/S KVITBJORN during the period from June 13 to June 24. The array consisted of 24 hydrophones attached to a kevlar strength member and suspended at depths from 24 to 313 m. The phones were spaced for an overall aperture at 30 Hz plus two nested subapertures at 400 HZ and 800 Hz. The individual hydrophone depths are listed in Table 1. Hydrophone number 24 became operational on June 17. The top-most hydrophone failed on June 19, probably due to a catastrophic encounter with an ice floe. Signals were recorded on a 32-track analog Sangamo Sabre V machine using 14 inch reel, 1 inch wide, 1.5 mil thick magnetic tape. Frequency response was from 5 Hz to 3000 Hz. Preamplifier and postamplifier gain switches permitted recording levels from 90 dB to 127 dB re 1 uPa, which includes ambient noise levels and signal levels well beyond the peak pressure of a Mk-61 SUS explosive charge (1.8 lb) at 1 km range.

The approach was to measure short range and long range explosive charge and projector signals. As part of post-experiment processing, explosive charge signals and broadband projector signals will be beamformed and deconvolved (to remove source signature effects) to extract the vertical directional impulse response of the ice. Narrowband projector signals will provide information on transmission loss and arrival structure. The space/time coherence of the beamformed signals will be studied as a function of time and ice conditions and as a function of range and frequency. Quantitative measures of ice conditions will be based on remote sensing data such as photography, laser profilometer and microwave passive imagery as provided by other MIZEX participants.

Explosive shot signal sources were deployed from helicopter and P-3 aircraft along radial tracks centered on the vertical array. Details of the shot data collected including date of the event, track bearing angle, source ranges and type of explosive (main charge weight and detonation depth) are summarized in Table 2. Narrowband and broadband programmed projector signals originating from POLAR QUEEN and LYNCH were recorded. Dates and hours during which these signals were recorded from the vertical array are summarized in Table 3.

An example of a short range shot signal is shown in Fig. 1. The first positive going spikes are the direct path shock and bubble pulse arrivals. The second arrival packet is the ice reflected energy. The ice reflected pulses are attenuated and show additional high frequency tails. An example

of narrowband signal energy is shown in Fig. 2. This is the 110 Hz line typical of transmissions from the LYNCH HLF-3 projector. In this case the signal-to-noise ratio (SNR) is high; however, the SNR was quite variable and depended on source range, ice conditions, and the ambient noise. A typical ambient noise spectrum is shown in Fig. 3. The top curve is for the usual station keeping duties of the ship; the lower curve was measured during "quiet ship" conditions when all ship generators and machinery were turned off. Thus, ship noise contributes significantly to the observed noise background as expected for hydrophones suspended close to the ship, and ship induced noise is of course characterized by strong lines. Another source of strong lines below 50 Hz is due to strumming as shown in Fig. 4. The dashed curve was measured on a day when there was no strumming; the solid curve from another day shows the strong, narrow strumming lines. Strumming was observed mainly on days when the ice floes were separated by large open water areas and the ship's drift velocity was high.

The data set is of the quality and breadth to satisfy the processing objectives of the experiment. In spite of the noise sources shown above most of the short signals were at a high level relative to the noise, and for narrowband processing most of the projector lines fall by chance between strong noise lines. For example, the background noise measured at one time for 100 Hz and 300 Hz was approximately 72 dB re 1 uPa/Hz, a level not much higher than the expected ambient noise level. After all shot runs were completed and all projectors had been shut down the vertical array continued to record air-gun signals which will provide information about the bottom environment. In all, some 370 shot signals and 105 hours of projector signals were successfully recorded.

Table 1. Deployment depths of hydrophones.

Sequence	1	2	3	4	5	6	7	8
Phone ID	4	6	7	8	9	10	11	12
Depth(m)	24.4	72.4	96.4	120.4	144.3	168.3	192.3	216.3
Sequence	9	10	11	12	13	14	15	16
Phone ID	13	14	15	16	17	18	19	20
Depth (m)	240.3	264.3	288.3	297.9	299.7	301.5	302.4	303.3
Sequence	17	18	19	20	21	22	23	24
Phone ID	21	22	24	25	26	27	28	29
Depth (m)	304.2	305.1	306.9	307.8	308.7	309.6	311.4	313.2

Table 2. Explosive charge deployments.

Date	Aircraft	Bearing (degrees)	Max range (km)	Type of Charge Weight(kg)	Depth(m)	Range(km)	Number
6/16	Helo	320	19	0.82	91	4-19	21
				0.82	244	1-19	20
				10.0	244	4-19	17
6/17	Helo	50	22	0.82	91	4-22	19
				0.82	244	1-22	23
				10.0	244	4-9	6
				25.0	244	10-22	9
6/18	Helo	0	46	0.03	244	0.5-5.	8
				0.82	91	0.5-46.	20
				0.82	244	0.5-46.	19
6/10	Helo	25	47	0.82	91	0.5-47.	17
				0.82	244	0.5-47.	16
6/21	Helo	320	33	0.82	91	1-33	15
				0.82	244	1-33	19
				10.0	244	4-8	4
				25.0	244	9-33	11
6/22	P-3	270	400	0.82	244	1-50	11
		315		0.82	244	1-50	11
		0		0.82	244	-100to+400	19
		45		0.82	244	1-50	11
		90		0.82	244	1-50	11
6/24	P-3	270	400	0.82	244	1-50	11
		315		0.82	244	1-50	11
		0		0.82	244	-100to+400	19
		45		0.82	244	1-50	11
		90		0.82	244	1-50	11

Table 3. Hours during which projector signals were recorded.

Date	Hours (Zulu Time)					
14	0948-1335	1515-1603	1645-1900			
15	0956-1130	1154-1548				
16	1907-2400					
17	0000-1057	1552-1826				
18	0615-1030	2358-2400				
19	0000-0003	0150-0900	0917-1200	1255-1600	1624-1800	1852-2400
20	0000-0400	1023-1255				
22	1255-2136	2150-2400				
23	0000-0200	0211-0425	0432-1200	1229-2030	2330-2400	
24	0000-0521	0530-0900				

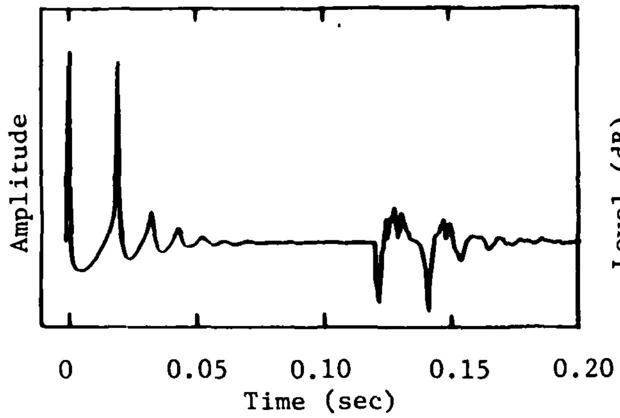


Fig. 1. Shot signal at 0.67 km range. Explosive charge: 0.82 kg at 244 m depth.

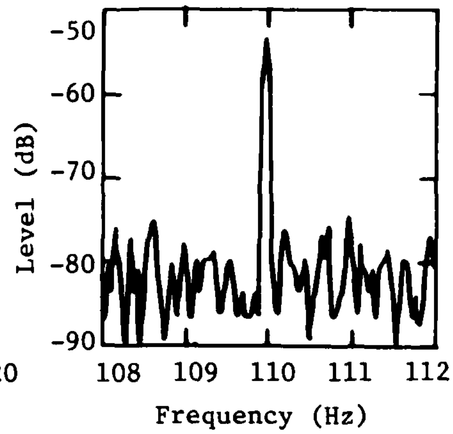


Fig. 2. Projector signal from HLF-3 source aboard US LYNCH. Analysis bandwidth = 60 mHz.

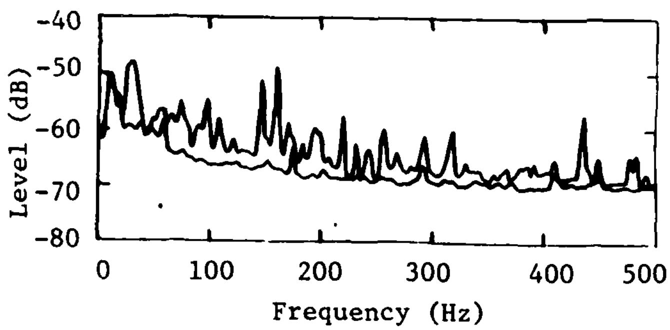


Fig. 3. Measured noise spectrum. Lower curve is for "quiet ship" conditions.

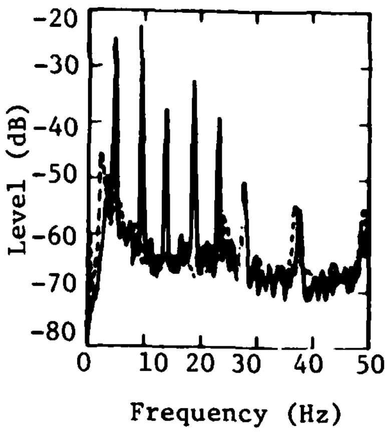


Fig. 4. Measured noise spectrum with strumming - and without---.

CTD and Deployment Activities Aboard USNS LYNCH During First Leg of NRL Cruise 707-84 for the Marginal Ice Zone Experiment

Charles W. Votaw and Stephen C. Wales

During May and June of 1984 the USNS LYNCH participated in ONR's Marginal Ice Zone Experiment (MIZEX) in the Fram Strait and northern Greenland Sea. This cruise was composed of two legs during May and June respectively. During the first leg the LYNCH deployed an acoustic source, transponders, current meters, and surface drifting bouys; recovered current meters; and made CTD measurements along a transect across the Fram Strait. During the second leg the LYNCH towed the HLF-3 acoustic source, recovered the acoustic source and a transponder, and made XSV, CTD and meterological measurements. It also made cavitation measurements for a non-MIZEX project. This article summarizes the CTD and deployment activities during the first leg of the cruise. The reader is refered to other articles for an in-depth description of the purpose of each of these experiments and their coordination with other facets of MIZEX.

The princopal objective of this leg was to make a large number of instrument deployments in support of MIZEX. These deployments with approximate positions are summarized in Table I. The first deployments scheduled were for the Wood's Hole Oceanographic Institute's (WHOI) moored acoustic source and its three position transponders. These were successfully deployed as scheduled. During the second leg the source and one transponder were recovered. The source operated successfully throughout the experiment.

The LYNCH was next scheduled to recover a University of Washington (UW) current meter mooring C-8, but it was decided to delay the recovery until after other deployments to provide some badly needed deck space. UW moorings FS-7 and FS-8 were deployed next. Following this the Lamont-Doherty Geological Observatory's (LDGO) 1983 mooring was recovered. The next set of deployments scheduled were for the LDGO triangular array of current meters at the ice edge. These deployments required that the bathymetry, line streach, and the deployment dynamics be known to high precision so that the current meter would be at a very shallow depth. Four attempts were made to deploy the current meter strings in this triangle, only one of which was successful. Because of the difficulty of cutting the line on the deck, necessitated by an uncertain position of the ice edge, as opposed to premeasured lines, three of these moorings turned up with the subsurface floats floating on the surface. The unsuccessful attempts were recoved so no equipment was lost.

During the attempts at launching the LDGO current meters, two of the ARGOS bouys from Laboratoire D'Oceanographie Physique were deployed along the ice edge. These were originally scheduled to be deployed along the northern ice edge but were deployed in this location due to time constraints. See Table I.

Following the LDGO current meter work a CTD transect was made of the Fram Strait. Beginning near the ice edge at 78 55'N, 0 30'E CTDs were taken every degree in longitude to 7 30'E, or just over 10 nms apart and half degree spacings thereafter to 9 30'E. Other CTDs were taken near the ice

edge and in the vicinity of the WHOI source. A total of 15 CTDs were taken throughout the first leg. The third ARGOS bouy was deployed near the Eastern end of this transect.

Following the CTD transect scientific operations were interupted for nearly two days due to rough weather. On the afternoon of the 27th, operations resumed with the final current meter deployments and recovery for UW. Current meter strings FS-6, FS-5, and FS-4 were successfully deployed and the previously deployed current meter C-8 was recovered.

Satellite navigation was used through out the cruise and positions were recorded and at every satellite fix. LORAN-C was found to be unsatisfactory at these latitudes. Bathymetry was recorded throughout the leg on both 3.5 kHz and 12 kHz recorders.

Table I - Approximate Deployment Locations and Times

	Time (GMT)		Deployment Positions	
Wood's Hole Ocean. Inst.				
Moored Source	21 May	0655	78 59.3'N	6 58.6'E
Transponder #1	21 May	0847	79 00.0'N	6 58.6'E
Transponder #2	21 May	0922	78 59.1'N	6 51.2'E
Transponder #3	21 May	1002	78 59.0'N	7 12.0'E
Univ. of Wash.				
Current meters FS-4	28 May	0305	78 39.0'N	4 05.0'E
Current meters FS-5	27 May	2248	78 42.8'N	5 33.9'E
Current meters FS-6	27 May	1714	78 40.2'N	6 19.6'E
Current meters FS-7	21 May	2021	78 53.7'N	8 05.2'E
Current meters FS-8	22 May	1256	78 04.3'N	3 46.1'E
1983 meters C-8	28 May	0830	Successful	recovery
Lab. D'Ocean. Phys.				
ARGOS bouy #5092	23 May	1135	79 18.6'N	1 54.8'E
ARGOS bouy #5087	23 May	1300	79 20.2'N	3 00.8'E
ARGOS bouy #5096	25 May	1012	78 56.4'N	7 37.0'E
Lamont-Doherty Geol. Obs.				
1983 current meters	22 May	1800	Successful	recovery
Current meters #1	23 May	0254	(See text)	
Current meters #2	23 May	2144	78 46.3'N	0 10.2'E
Current meters #3	24 May	0228	(See text)	

In addition Lamont-Doherty took 15 CTD measurements along the ice edge and along 78 55'N from 0 30'E to 9 30'E in 1 degree intervals.

HLF-3 acoustic source activities aboard the USNS LYNCH during NRL Cruise 707-84 for the Marginal Ice Zone Experiment

Stephen C. Wales, U.S. Naval Research Laboratory, Washington, D.C. 20375

During May and June of 1984 the USNS LYNCH participated in ONR's Marginal Ice Zone Experiment (MIZEX) in the Fram Strait and northern Greenland Sea. This cruise was composed of two legs during May and June respectively. During the second leg, discussed here, the LYNCH towed the HLF-3 acoustic source, recovered the acoustic source and a transponder, and made XSV, CTD and meterological measurements. It also made cavitation measurements for a non-MIZEX project. This article describes the HLF-3 and XSV activites aboard the LYNCH during the second leg. While this section includes some indication of the other activites aboard the LYNCH, the reader is refered to other articles for an in-depth description of them.

On arriving in the operation area the LYNCH began deploying the HLF-3 source at 2100 Z on 8 June after encountering ice. The deployment went very smoothly and the source was in and operational within two hours. The source was turned on at 0000 Z 9 June and the LYNCH began sailing her scheduled tracks. The LYNCH was generally able to pull the source comfortably at 7.5 knots, under good conditions she made 8 knots and in rough weather the speed dropped to 5.5 knots. Source waveforms were broadcast as directed by the source schedule [1] with only a few minor variations due to operator error or routine source maintenance. The source worked flawlessly throughout the experiment.

The towing tracks were generally as intended. However, ice was encountered repeatedly along the northern and western legs in unreported positions, and this required that these tracks be restructured to avoid the ice. This was expected during the planning phase due to the uncertainty in ice location. Figure 1 shows the tow tracks followed by the LYNCH. Tracks were also changed, at the request of SVERDRUP, to avoid the immediate vicinity of the SVERDRUP and to obtain more time between the northern region between SVERDRUP and KVITBJORN. The final circuit to the south was shortened to accommodate the latter change.

Beginning on the evening of 12 June the LYNCH was accompanied by the Soviet ship SENEZH. The SENEZH stayed with the LYNCH throughout her operations only leaving her when she was well on her way to Reykjavik after the experiment. With one exception, she did not interfere with the LYNCH's operations.

The HLF-3 source was recovered near the WHOI moored source's location without problems at 0700 Z 19 June, slightly ahead of schedule. The moored source was then recovered, but due to worsening weather no attempt was made to recover the transponders at that time. The LYNCH then proceeded north to the ice-edge and began her participation in the synoptic CTD survey. She accomplished two of her three scheduled legs and the NORDA cavitation work before breaking off for another attempt at recovering the transponders.

After returning to the WHOI moored source site the transponders were located and released, one at a time. The first transponder was recovered by the SENEZH, the second was lost, and the LYNCH recovered the last one. After this, the LYNCH redeployed the HLF-3 source AT 1300 Z 22 June and began a final tow at 1430 Z to the southwest along a previous track. She recovered the source at

0530 Z 24 June and arrived in Reykjavik, Iceland on 28 June where the scientific personnel disembarked.

During the experiment the source was monitored by the scientific personnel at all times. Source information was recorded on 7-track analog tape at 15/16 ips, in IRIG Wideband Group I format, according to Table I. The FM bandwidth is 625 Hz. Source operations were also recorded in a written log by time, with waveform type, input, depth, sea temperature, and hydrophone and accelerometer voltages recorded hourly. Additionally, spectrum plots, taken everytime the source waveform was changed, and a six-channel brush recorder provided a visual display of the information being recorded.

42 Mark 61 SUS charges, 1.8 lbs TNT with a 1.1 oz tetryl booster, were dropped from 1245 Z 12 June to 1015 Z 13 June at half-hour intervals, 3 were duds. All charges were set for nominally an 800 ft depth. Drop time, detonation time and position were logged for each drop. The difference in the times will provide the actual shot depth.

24 Sippican expendable sound velocimeters, XSV-02s, were dropped during the cruise. Along with CTD information taken from the LYNCH and other ships, these are expected to provide the necessary sound velocity information to interpret the acoustic data. The XSVs were dropped in a pattern intended to cover the entire LYNCH towing area concentrating more on the northernmost region where the sound speed profile was most rapidly changing. There were an insufficient number of XSVs to duplicate locations and look for sound velocity variablity, however one XSV was dropped at the same location as a CTD measurement. Agreement as judged from the thermal printer plot, was very good. The signals from the XSVs were recorded on 4 cassette cartridges using an Hewlett-Packard HP-85 personel computer and a Sippican Mark 9 interface box.

Satellite navigation was used through out the cruise and positions were recorded every half-hour and at every satellite fix. LORAN-C was recorded on the quarter-hours and was found to agree with the satellite fixes at the lower latitudes. Bathymetry was recorded throughout both towing phases and enroute to the operations area on both 3.5 kHz and 12 kHz. During the synoptic survey period the 12 kHz transducer was used with the CTD device and the 3.5 kHz transducer was under repair.

Acoustic operations aboard the LYNCH went nearly flawlessly during MIZEX and all major acoustic goals aboard the LYNCH were accomplished. MIZEX participants who have questions concerning the HLF-3 source data, XSV data, navigation, or bathymetry, should contact the author. The author would like to thank the officers and crew of the LYNCH and the members of the scientific party who made this a particularily smooth cruise. Special thanks are in order to the individuals who made the acoustic operations work, E. Daniel McCloskey of Hydroacoustics, Inc., John Kemp of Wood's Hole Oceanographic Institute, Harold Ware of the Naval Underwater Systems Center, Rubin Naber of the Naval Research Laboratory, and James Hannon of Sippican Inc., which loaned us the Mark 9 box and the HP-85.

1. F.R. DiNapoli, "Corrections to LYNCH HLF-3 Towing Schedule" 401Y-34, April 24, 1984, and encls. "MIZEX-84 LYNCH HLF-3 Towing Schedule; mod-3," 401Y-16, and "Proposed MIZEX-84 transmission schedule for POLAR QUEEN, mod-1," 401Y-32, Naval Underwater Systems Center, New London Conn.

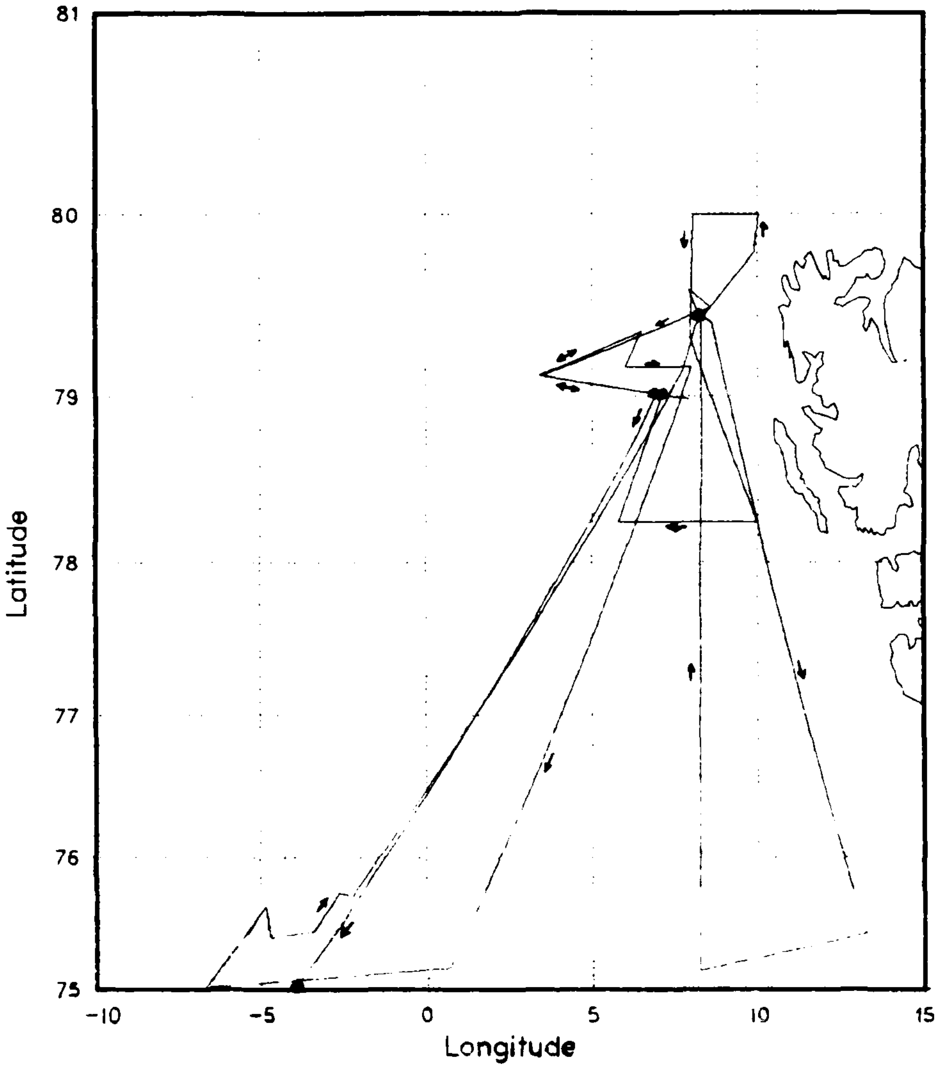


Figure 1. HLF-3 source tow tracks by the USNS LYNCH during MIZEX, 9-24 June 1984, in the Fram Strait. Dots indicate starting and ending points, arrows the ship's direction.

Table I - Recorded HLF-3 source information

Item	Tape Ch.	Mode	Brush Ch.	Comments
Tach Signal	1	Direct	-	
Clock (IRIG-B)	2	Direct	3	On brush as slow code
Source input waveform	3	FM	1	Add 10 dB
Hydrophone waveform	4	FM	2	-184.8 dB/volt/μPa
Accelerometer	5	FM	4	3.12g's/v, varies with frequency
Depth	6	FM	5	68 m/volt
Sea temperature	7	FM	6	10° C/volt

ACOUSTIC TOMOGRAPHY SOURCE

Robert C. Spindel
Woods Hole Oceanographic Institution

An autonomous, moored, acoustic source was deployed on Leg 1 of the USNS Lynch in May, 1984, to assess the stability of surface reflected acoustic paths for tomographic application. The source transmitted a 224 Hz carrier, phase modulated by a binary, maximal-length shift-register sequence, similar to the type of signal transmitted during several tomography experiments. Minor adjustments in signalling parameters were made to account for Doppler shifts due to the time-varying ocean surface. The signal was received by hydrophones suspended through the ice by the MIT/WHOI scientific party aboard the MV Kvitbjorn and by hydrophones deployed by the HU Sverdrup.

The source was moored at a depth of 175 meters in 1207 meter (corrected) water at 78°59.'3 N, 6°58.'6 E. It began transmitting at 0000Z on Julian day 161 (9 June) and ceased at 0000Z on day 171. The transmission sequence consisted of two hours of continuous transmission starting at 0000Z each day, and approximately 3 minutes of transmission at the start of each hour beginning at 0300Z and lasting through 2300Z. The binary sequence consisted of a 63 bit code, with 14 cycles of the 224 Hz carrier per digit. Each digit modulated the carrier +/- 82.82 degrees depending on whether the digit was a zero or a one. This modulation angle results in maximum signal-to-noise ratio for the particular signal parameters used. The total transmission time for an entire binary sequence was 63 bits x 14/224 seconds/bit = 3.9375 seconds. The once daily two hour transmission consisted of a continuous repetition of this sequence; the hourly 3 minute transmissions consisted of 48 repetitions.

The source mooring was equipped with a system to measure the position of the source as the mooring moved in response to tidal and other forcing currents. An acoustic interrogator measured the slant range to three transponders in an equilateral triangle about the base of the mooring at a distance of about 1 km from the mooring anchor.

The status of data return is very preliminary. The source signal was heard on Sverdrup hydrophones and it is assumed that successful recordings were made. The signal was recorded on a special digital receiver connected to a Kvitbjorn hydrophone, but there has been some problem reading that instrument's tape and it is not yet certain whether it will be successfully read. The signal was also recorded by the MIT/WHOI acoustic array. These tapes have not yet arrived in the U.S. and, therefore, their quality has yet to be evaluated. However, since there is triple redundancy in data recording the expectation of successful data return is high.

Analysis of the data with respect to tomography application is scheduled for late 1984 and early 1985.

SCIENTIFIC ACTIVITIES ABOARD H.U.SVERDRUP

F.R.DiNapoli, NUSC,Code 01Y

NUSC deployed a long bottomed array at approximately 80°N and 7°E on June 9 utilizing the Norwegian Defense Research Establishment vessel H.U.SVERDRUP. Acoustic signals were recorded from the acoustic source towed in open water by the Lynch and from another source suspended from the POLARQUEEN in the MIZ from June 9 to June 19.

On June 19, the Soviet AGOR "SENYEZ" cut the mooring line to the surface telemetry buoy. A second line from the surface buoy to the bottomed array was broken by heavy seas shortly after the interference by "SENYEZ" and the experiment had to be prematurely terminated.

The SVERDRUP then obtained sound velocity versus depth measurements on a track from the site to the position of the POLARQUEEN.

The overall quality of data collected was generally good, but we did experience the following difficulties:

- o A failure of unknown origin prevented us from recording data from the full aperture;
- o Severe strumming on the short vertical portion of the array made that data totally unusable;
- o Data from the refraction run was contaminated by SVERDRUP's own ship noise.

A total of 240 hours of data were obtained during the experiment. A review of hourly in-situ ambient noise measurements show that the average ambient noise has approximately a 10 db spread and an average value which is rather high. We suspect that this high ambient noise may be due to shipping, but the number of ships observed in the vicinity of the SVERDRUP position was not high.

BIOLOGY

LIFE CYCLES AND SECONDARY PRODUCTION OF DOMINANT COPEPODS

H.J. Hirche and R.M.Bohrer

Life cycles and secondary production of dominant herbivorous copepods were studied during 5 mesoscale transects in the MIZ, 3 Large Scale Oceanography transects and an eddy tracking. Three different approaches were used:

1. Egg production: The egg production of female Calanus finmarchicus and Calanus glacialis is strictly correlated with food supply. Since the females are not growing in this stage, egg production can be taken as a measure of their net production under observed nutrient conditions.

   Healthy females were selected from bongo net hauls (500 um and 700 um mesh size) from the upper 150 m. The nets had closed cod ends to prevent damage to the animals.

   With C. glacialis 20 experiments were carried out on 11 stations during Large Scale Transects. This species is found almost exclusively under the ice. Eggs were produced only on stations on the Eastgreenland shelf.

   With C. finmarchicus 120 experiments were done on 57 stations. Stations were closely spaced in the MIZ and during eddy tracking. According to the hydrography and phytoplankton abundance egg production showed steep gradients in the MIZ. In general egg production was low under the ice. Maximum production was found in the MIZ, the position of the maximum depending on the front. Towards the open Atlantic egg production apparently decreased.

   In the laboratory the influence of experimental condition upon egg production was studied. Females were incubated in ambient seawater in filtered seawater and also in algae cultures. In addition maximum egg production was studied at different temperatures and optimum food conditions (algae cultures).

2. Digestive enzymes: The activities of the digestive enzymes amylase and trypsin give an indication of the physiological condition of copepods.

   Our special interest focused on the overwintering stage, when the animals reduce their metabolism and stop feeding. More than 100 homogenates of the copepodid stage V (CV) of Calanus finmarchicus, C. glacialis and C. hyperboreus were prepared from 500-200 m and from surface tows. These homogenates are being analyzed in the laboratory.

3. Moulting experiments: Moulting rates are a direct measure of developmental time. In overwintering stages development is blocked.

18 experiments were set up with _C. finmarchicus_ CV from surface tows. Animals were kept at ambient temperature to follow their development.

On all stations development has already ceased as animals had physiologically prepared for overwintering.

Nitrogen dynamics in the retreating ice edge of the East Greenland Sea

Walker O. Smith, Louis A. Codispoti and Sharon L. Smith

During MIZEX-84 our group conducted experiments designed to assess the distribution of nitrogen (nitrate, ammonium, urea, particulate nitrogen, zooplankton nitrogen), rates of nitrogen assimilation and turnover (nitrate, ammonium and urea uptake by phytoplankton; zooplankton excretion of ammonium and urea; ammonium regeneration by bacteria and microzooplankton) and causal mechanisms of the ubiquitous subsurface ammonium maximum we observed in the study region in 1983 (Smith et al., submitted). To characterize the nutrient, phytoplankton and zooplankton fields within the marginal ice zone, discrete water samples were taken at stations in the MIZ from depths corresponding to known percentages of surface radiation or from standard depths. Generally samples were analyzed through 150 m. Zooplankton were sampled by an electronic opening/closing nets (mesh size 303 um) to estimate the macrozooplankton biomass from 0-25, 25-50, 50-100, 100-200, and 200-500 m. Vertical bongo tows from 0-100 m were also conducted to collect animals for experimentation. Chlorophyll was measured to quantify phytoplankton biomass at sea. A total of 59 stations were completed in which the nutrient and phytoplankton distributions were both analyzed; zooplankton biomass was measured at 48 stations.

Nutrient (nitrate, urea and ammonium) and carbon uptake were measured using ^{15}N- and ^{14}C-isotopes. Samples from 33 stations were incubated in an on-deck incubator cooled to surface seawater temperatures in bottles fitted with neutral density screens designed to reduce the light intensity to that of the depth sampled. Ammonium regeneration by bacteria and microzooplankton was estimated at 18 stations using an ^{15}N-NH_4 isotope dilution technique (Harrison et al., 1983). Macrozooplankton excretion rates were estimated by placing recently collected animals in 125 ml of filtered seawater and measuring the change in ammonium and urea concentrations after an incubation at 1^{o} C. A total of 27 macrozooplankton excretion experiments were completed.

Most of our data are presently being analyzed, but preliminary results indicate that the large spatial/temporal patterns in nitrogen (dissolved and particulate) distributions that we observed in 1983 were also present in 1984. For example, ammonium showed a distinct subsurface maximum (Figure 1) and the concentrations detected were similar to those found both last year and in the Bering Sea (Saino et al., 1983). We do not at this time understand the role of the marginal ice zone in the initiation and maintainance of this feature. Phytoplankton biomass as measured by chlorophyll also showed a distinct subsurface maximum (Figure 1) which seemed to be related to the halocline created between the meltwater and more saline waters of North Atlantic origin. The spatial variations of chlorophyll also varied widely within the marginal ice zone (Figure 2). The data presented in Figure 2 are those collected in the first mesoscale grid survey.

Nitrogen dynamics in the retreating ice edge of the East Greenland Sea

Walker O. Smith, Louis A. Codispoti and Sharon L. Smith

Chlorophyll levels were extremely low in regions of heavy ice cover and increased markedly at the ice edge. There is some indication that chlorophyll concentrations were beginning to decrease away from the ice. Measurements taken simultaneously onboard the F.S. VALDIVIA will clarify this distribution.

Zooplankton were dominated by the copepods *Calanus finmarchicus*, *C. hyperboreus* and *Metridia longa*. Also found were *Calanus glacialis* and *Pseudocalanus* spp. Although quantitative data are as yet unavailable, zooplankton were noticeably concentrated in the upper 25 m of the water column. Preliminary evidence indicates that *C. finmarchicus* copepodids (stage V) may have already entered diapause during the study.

Much work remains before we fully understand the roles of each group of organisms in the formation of the subsurface ammonium maximum, as well as its relationship to the marginal ice zone. Hopefully the data we collected will enable us to appreciate the role of nitrogen as a controlling mechanism in the ice edge system of the East Greenland Sea.

Research sponsored by the Office of Naval Research and NSF grant DPP-8319470.

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Nitrogen dynamics in the retreating ice edge of the East Greenland Sea

Walker O. Smith, Louis A. Codispoti and Sharon L. Smith

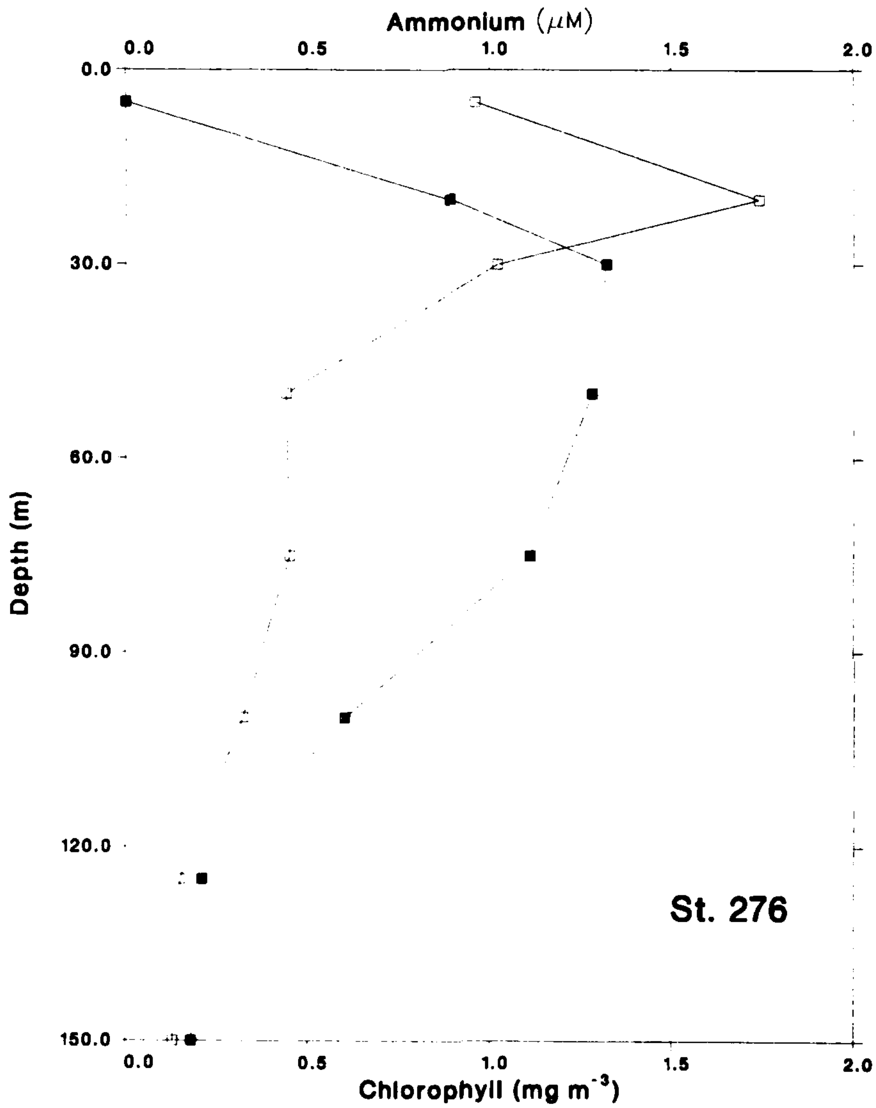


Figure 1. The vertical distribution of ammonium (closed squares) and chlorophyll (open squares) at a station within the MIZ.

Nitrogen dynamics in the retreating ice edge of the East Greenland Sea

Walker O. Smith, Louis A. Codispoti and Sharon L. Smith

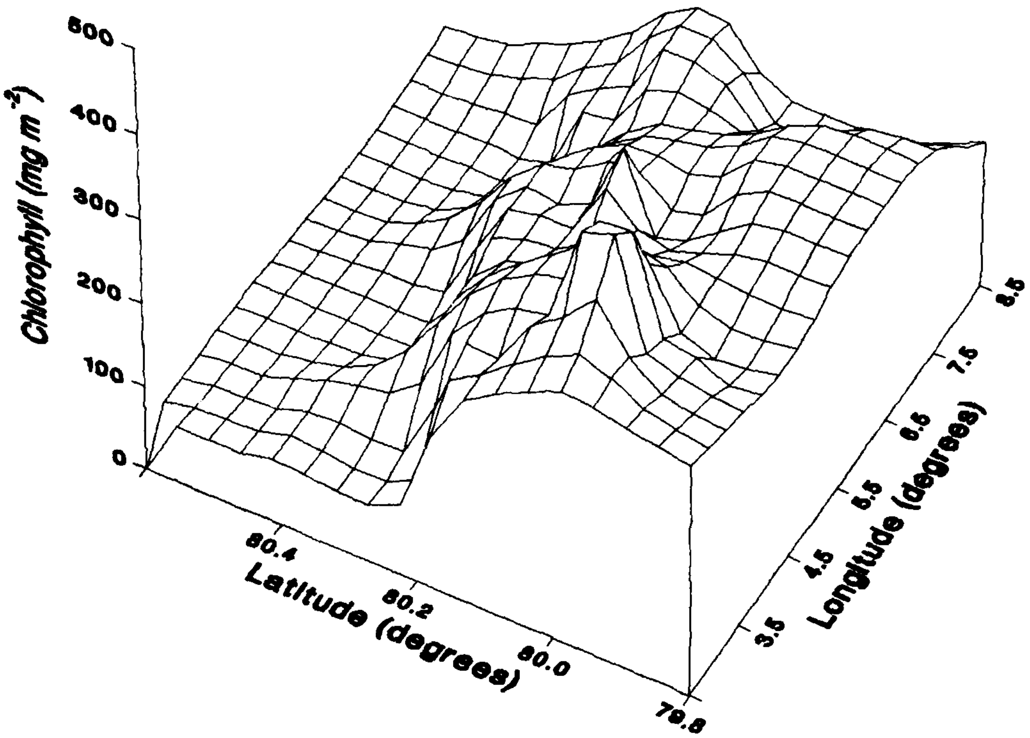


Figure 2. Three-dimensional plot of chlorophyll concentrations as observed during the first mesoscale survey (Stations 172-203).

Biological Production

Hanns-J. Neubert

The aim of the biological production program was to collect data for primary and heterotrophic production at the ice-edge region and on three large-scale transects in the open water of the Fram-Strait (see Fig.).

The primary producers are basically important for the whole productivity of an ecosystem. Their species composition is dependent upon hydrographic processes and chemical distribution patterns. The activity of bacteria gives information about the turnover of diluted organic substances and the recycling of nutrients.

Primary productivity was measured with the C-14-method. At 37 stations samples were collected from 30-l-watersamplers. Sampling depths corresponded to light penetrations of 90%, 50%, 30%, 15%, 5%, 1%, and 0.1%. 200 ml of the samples were incubated on deck using PTFE-bottles darkened accordingly to the light depths and paralelled by dark bottles. The radioactivity of the samples was 10 µCi per 200 ml, incubation time 4 to 6 hours.

After filtration, the filters were deepfrozen. Beside measurements of light penetration (Quantameter), the global radiation and the alcalinity was measured.

For analysis of algal species composition and biomass, at 88 stations samples were collected from 1m, 10m, 20m, 40m, 60m, 80m, 100m, and 150m, and fixed.

Bacterial production was measured by incorporation of H-3-thymidine into bacterial DNA. Also 37 stations were sampled, alternating the stations of primary production measurements. Samples came from 5 depths regularily distributed over the water column. 50 ml of water from the hydrographic rosette (1.7-l-samplers) were incubated with 5 µCi H-3-thymidine for 3 to 4 hours. After filtration and rinsing with TCA the filters were also deepfrozen.

Samples for analysis of bacterial biomass (epifluorescent micro-

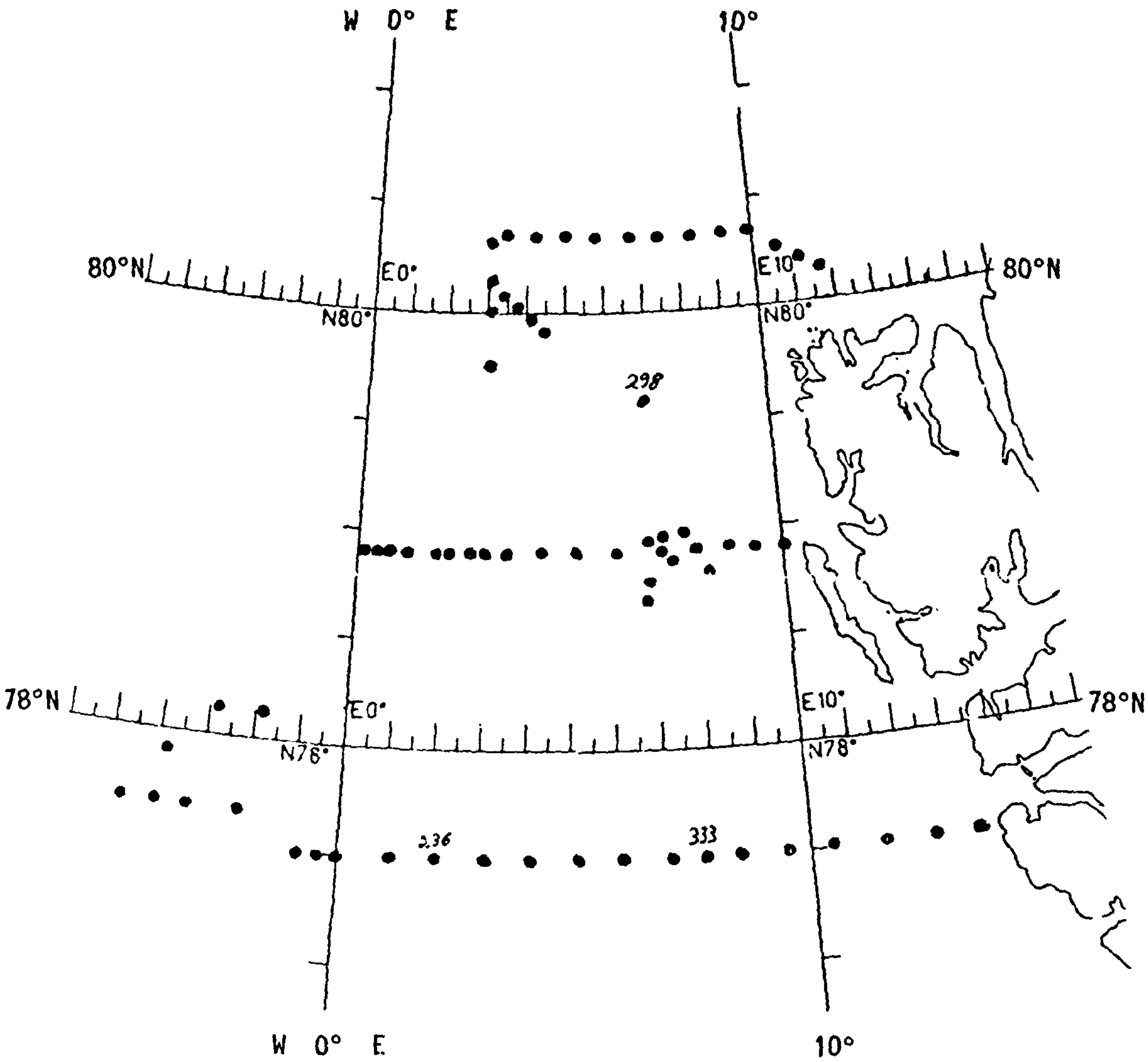
scopy) were taken from 10 depth at 88 stations.

At station no. 236 samples for quench corrections were taken, at station no. 298 the influence of different bottle materials (glass, PVC, PTFE) on the production was tested.

Natural Tritium Content

Hanns-J. Neubert

At station no. 333 (see Fig.) a hole of >3000 m was found. To get information about the age of the water in that hole and the turnover of the deepwater, samples from 18 depths were taken for analysis of the natural concentration of tritium (H-3).



MIZEX '84, VALDIVIA 21, biological stations

The Phytoplankton and the Primary Production

M.E.M. Baumann, RWTH Aachen, Bio I, Abt.f.Syst.u.Geobot.

1. Distribution of Phytoplankton

The aim of these investigations was the vertical and horizontal distribution of the phytoplankton. Samples were taken at every biological station (see tab.) from the surface down to a light depth of 16 %. The light depths were determined by secchi disk and quantameter.

2. Primary Production

The primary production was estimated on the basis of ^{14}C- assimilation for different light depths (7o%, 5o%, 3o%, 16%) with the help of a recently developed incubator. The diurnal changes of the light intensities were measured by a photocell installed on a retractable girder above the crow's nest and automatically simulated in the incubator with fluorescent tubes of a similar spektrum as the solar light. The light depths were simulated with different filters, the temperature was adjusted with the aid of two aggregates at every station where measurements were undertaken (see tab.). The production measurements were carried out in untreated samples and in 2o um and 1o um fractionated samples to get an idea on the contribution of the nannoplankton to the primary production.

3. Isolation and Cultivation of Phytoplankton

The dominant diatom species were isolated from the phytoplankton and cultivated in filtered seawater to which nutrients had been added. The following species were isolated: Thalassiosira gravida, T. nordenskiöldii, Chaetoceros decipiens, C. socialis, C. borealis, Amphiprora hyperborea, Bacteriosira fragilis, Lauderia borealis.

and some _Fragillaria_- and _Coscinodiscus_ species. In addition, primary production was measured on these under natural conditions in the incubator to determine the contribution of these respective species to the total sum of primary production. The enlisted diatom species were taken home for additional eco-physiological experiments.

4. Further Primary Production Measurements

During the 2nd minidrift, some "in situ"- incubations could be undertaken. The incubation bottles were fastened to a rope according to the appropriate light depths and were allowed to swim behind the stern of the ship in the open water where ice floes did not disturb the incubation. Furthermore, isolated algae material was incubated below the ice through a hole drilled by the glaciologists at station 299 to get an idea about the productivity of the algae under these light defficient conditions and to test the practicability of such measurements.

5. Light Measurements

Vertical profiles of the light conditions in the natural water column were measured from the ship and from the rubber boat in open water and between ice floes in pack ice. The diurnal changes of the daylight were measured continously.

Station No.	Watertemp. °C	Secchidepth m	Depths of the incubated samples m
174	o,6	17	o,6,11,17
178	o,6	17	o,6,11,17
182	-1,2	2o	o,5,11,2o
185	o,3	12	3,5,12,3o
188	1,3	6	2,3,6,2o
19o	2,2	11	-
198	-o,8	19	5,8,21,52
2o1	1,5	9	4,7,1o
2o3	2,6	8	4,6,9
1. Minidrift	-o,5	11	3,5,7,11
"	-o,5	11	5,8,12,4o
223	-1,o	16	o,9,18,28
224	o,3	1o	4,11
225	-o,6	8	5,6
226	-1,4	18	5,7,11,18,28,43
229	-1,4	21	5,8,14,21
232	-2,5	2o	8,14,2o,1oo
239	-1,6	25	1o,18,29,35,75
245	-o,5	1o	5,8,12,2o,3o
253	-o,8	25	7,16,25, 39,6o, 89
26o	o,3	11	5,8,12,19,3o,45
264	o,o	11	5,8,12,2o,3o,45
271	-o,5	18	13,2o
272	-1,9	26	o,18,29
273	-1,7	15	o,6,11,17
275	3,2	11	4,7,11
277	o,6	15	o,5,9,15
28o	-1,o	14	o,5,9,14
283	-1,5	22	o,9,16,25
287	1,3	1o	4,6,1o
288	4,o	6	o,5,7
291	1,5	7	o,3,5,8
294	1,5	7	o,3,5,8
296	-1,4	8	o,8
296 (2)	o,o	8	1,5,1o
297	-1,8	8	o,2,8
298	-o,4	7	1,3,5,7
299	o,o	1o	1,4,7,1o
3oo	-1,7	12	2,5,8,12
3o2	-1,5	14	3,6,1o,14
3o4	-o,9	12	2,4,8,12

Tab. Primary Production: On these stations primary production measurements were undertaken during the MIZEX - cruise 1984

Phytoplankton Ecology and Zooplankton Grazing

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Within the framework of the joint biological program on board the RV 'Polarstern' we concentrated our sampling program on phytoplankton, particulate matter and microzooplankton in the euphotic zone and below, down to 200 m. Samples were preserved for the analysis of species composition and after filtration deep-frozen for subsequent measurement of seston, particulate carbon and nitrogen and chlorophyll a. At each full-program station, dominant copopod species were sorted out and grazing experiments performed under natural feeding conditions. An additional program was the measurement of photosynthetic active radiation essential for phytoplankton growth in leads and under ice-floes. Altogether, over 40 stations were occupied. Preliminary results showed that plankton abundance and species composition are largely governed by the hydrographic structure of the water masses and the extent of ice cover. Three main areas differing in seasonal development of phyto- and zooplankton were encountered on the east-west transect through the Fram Strait. The first is the Ice Edge Zone strongly influenced by North Atlantic waters with high phytoplankton standing stocks and correspondingly low water transparency. A characteristic feature was a subsurface maximum of algae below the low-saline ice-melt water. Species composition pointed to a post-spring bloom of phytoplankton. This zone was also characterized by high concentrations of actively grazing copepod populations. Very clear waters sparse in plankton constitute the second region in the center of the pack-ice zone. The few copepods present were still in their hibernating resting stage and had not yet started grazing. The third area are the large polynias at the East Greenland shelf edge. Here the phytoplankton spring bloom was approaching its peak with actively feeding meroplanktic larvae and copepods. A much more detailed picture will be obtained after completion of the time-consuming analysis of the samples, which will take about a year.

Distribution of nutrients and organic substances

G. Kattner

According to the station grid of the CTD-measurements more than 2200 samples were taken for chemical analysis. At every station 12 or 24 samples were taken; major sampling depths were 500 m and until bottom. Nutrients - nitrate, nitrite, phosphate, silicate, and ammonia - were measured immediately from unfiltered samples by a Technicon AutoAnalyzer. Additionally all samples were filtered through glass fibre filters and preserved by mercury chloride for analysis of organic substances. These measurements will be performed in the institute in Hamburg.

In the upper water layer good correlations seem to exist between the nutrients and the biological activity. In the area of the ice edge the nutrient concentrations were rather low, which indicates a high productivity before or during the experiment. Especially nitrate was nearly exhausted in the euphotic zone and seems to be the limiting factor of the phytoplankton growth. The concentrations of the other nutrients were slightly higher, increasing all towards the ice covered regions. The concentrations of nitrate, silicate and phosphate increased with depths reaching maximum values near the bottom. Ammonia and nitrite, resulting from decomposition processes and release of zooplankton, showed highest concentrations at 30 to 80 m in the ice edge region. That seems to be in connection with zooplankton activity. The distribution of nutrients also permits a characterization of water masses. During the large scale survey the transport of water out of the Arctic Ocean could be identified by high concentration of nutrients. More than 20 μmoles dm^{-3} of silicate and 1.5 μmoles dm^{-3} of phosphate were observed in a layer between 50 and 100 m depth. For example, the silicate

concentration decreased from about 21 umoles dm^{-3} at 80 m to 6 umoles dm^{-3} below 100 m depth. Also the deep water nutrient distribution will help to identify and quantify water mass exchange and transport.

Additionally to the seawater analyses nutrients were measured in about 400 samples of melted sea ice. In co-operation with the group of CRREL, investigating sea ice properties, ice cores of 14 multi and first year ice floes were studied. Each core was analyzed at nominal 10 or 20 cm intervals. Silicate showed higher concentrations than the other nutrients with clear maxima especially in the multi year ice cores. In general the nutrient concentrations of the ice floes were lower than those in the sea water.

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